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A review on Energy-Efficient MAC Layer Protocols in MANET

KEYWORDS: Ad hoc network, sleep state, reasons of energy waste, MAC layer protocols.

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ABSTRACT A mobile ad hoc network is a system of various mobile nodes which are connected with each other in a random topology. The characteristics of MANET are lack of infrastructure, random topology, fast deployment, limited battery life. In this paper we conducted review on energy efficient MAC protocols and different techniques used in it. We have also differentiated various MAC protocols based on energy efficiency and other criteria.

I.INTRODUCTION TO MANET

The popularity of wireless networks has been increased tremendously in last few years compared to wired networks because of their mobility and wide applicability. Wireless nodes can be a laptop, PDA, Smart phones, etc. MANET vulnerabilities are lack of centralized management, resource availability, scalability, cooperativeness, Security, dynamic topology, limited power supply [1]. It is very difficult or impossible to replace a battery (like in a battlefield and disaster relief operation).

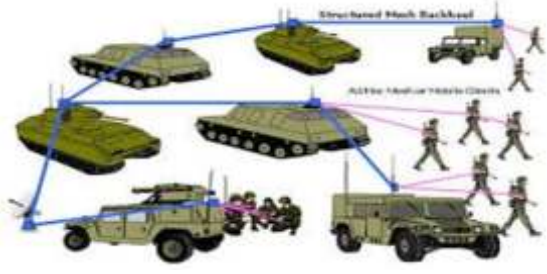


Fig.1 image of Ad hoc network

It is very important to do power conservation in MANET as it increases network lifetime and capacity of network [2]. Although we can do power conservation in all layers of network protocol stack, our main focus will be on MAC layer. In this paper we tried to provide a review of MAC protocols by keeping energy as main issue. The rest of the paper organised as follows. Section II focuses on sources of energy waste, low power MAC design guidelines and MAC classifications. Various energy efficient MAC protocols are reviewed in Section III.

Conclusion is given in section IV

II. MAC LAYER CLASSIFICATION AND DESIGN GUIDELINES

This section focuses on energy waste, low power MAC design guidelines and MAC classification.

A. Reasons of power waste

The major reasons of power waste in mobile computing devices include radio communication and data processing, with radio communication often being the dominate source of energy consumption. Data processing involves the usage of CPU, memory, hard drive, etc. Energy consumption in data processing is relatively very much less compared with that of the radios. In mobile ad hoc networks, communication related energy consumption includes the power consumed by the radios at the sender, receiver and intermediate nodes in the route from the source to the destination. Actually, at any time a mobile node in MANETs must be in one of the following four modes: transmit, receive, idle listening, and sleep. When a node is in transmit or receive mode, it is transmitting or receiving a packet. Idle listening mode means the node is neither transmitting nor receiving a packet, but is doing channel monitoring. This mode consumes power because the node has to listen to the wireless medium continuously in order to detect the arrival of the packet that it should receive, so that the node can switch to receive mode . When in the sleep mode, nodes do not communicate at all. Receive and idle mode consume similar amount of power, while transmit mode requires slightly larger amount. Nodes in sleep mode consume extremely low power.

Mode Of Mobile Node	Energy Consumption in mA
Sleep Mode	14 mA
Receive Mode	204 mA
Transmitting Mode	280 mA
Idle Mode	178 mA

Table1. Different modes of mobile node in MANET

Besides the power consumption in transmit, receive and idle listening, there exists other significant energy consumption in packet retransmission, node overhearing and protocol overhead. Retransmission is needed when collision occurs. When a packet is corrupted, it must be discarded and transmitted again. Retransmission increases energy consumption. And also, due to the lack of a centralized authority in mobile ad hoc networks, transmissions of packets from distinct mobile terminals are more prone to overlap, resulting in more serious packet collisions and energy loss. Overhearing means a node picks up packets that are destined for other nodes. Wireless nodes will

Volume - 5 | Issue - 1 | Jan Special Issue - 2015 | ISSN - 2249-555X

consume power unnecessarily due to overhearing transmissions of their neighboring nodes. Protocol overhead is generated by packets dedicated for network control and header bits of data packets. It should be reduced as much as possible because transmitting data packet headers or control packets also consumes energy, which results in the transmission of fewer amounts of useful data packets [3].

B. Low power Mac design guidelines

Energy efficient MAC layer protocol implementation can be done by obeying one of the following guidelines.

I) Reduce collision and followed retransmission

Collision must be avoided otherwise retransmission will take more time delay and energy consumption. Two interfering nodes must not transmit simultaneously. You can use code division multiple access (CDMA), time division multiple access (TDMA), and frequency division multiple access (FDMA).[3]

ii) Minimize idle listening

Idle listening consumes significant amount of power. We should power on the radio only when it is transmitting or receiving data preferably. Nodes in sleep mode are not aware about traffic relay so nodes must go in sleep mode and awake when necessary. This will result in significant energy saving. [3, 4]

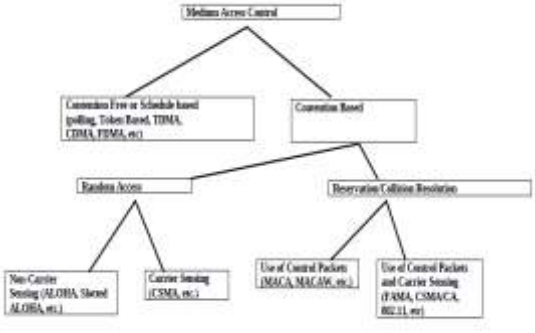
iii) Minimize overhearing

In broadcasting environment nodes lose their energy overhearing transmissions of their neighbor. One can solve overhearing problem by power off interfering nodes after they hear an RTS or CTS packet. [4]

iv) Minimize control overhead

Protocol header must be reduced as much as possible so that small packets don't consume more energy. Packet header compression results in significant energy saving. [4]

C. MAC classification



MAC protocols can be classified according to contention free and contention based classification.

In contention free protocols channelization is done in which available bandwidth is shared in time, frequency, or code. Multiple users can access the channel using any of FDMA, TDMA or CDMA technique. Random access protocols like ALOHA where station sends a frame whenever it has a frame to send. Slotted ALOHA divides the time into slots and each station can end only at beginning of time slot. CSMA sense the channel whether the channel is busy or not. If channel is free then only station is allowed to send[5]. MACA protocol uses additional signaling packets like RTS/CTS. Sender asks receiver whether it is able to receive a packet - Request to Send (RTS) IF Receiver agrees, it sends out a Clear to Send (CTS). Upon successful reception of packet receiver acknowledges. MACA doesn't solve exposed terminal problem. [6] MACAW uses per flow fairness compared to MACA which uses per node fairness. It solves the hidden terminal and exposed terminal problem. [7]

III. VARIOUS MAC LAYER PROTOCOLS

A. EE-MAC

In Energy Efficient MAC the basic mechanism is to reduce energy consumption without drastically reduce network performance. EE-MAC is based on IEEE 802.11 and its power saving mode, and can give valuable data to the network layer for route discovery. EEMAC is to elect master nodes from network. Master nodes continue conscious all the time and route packets in the ad hoc network and slave nodes remain in an energy-efficient mode and wake up frequently to check whether they have packets to receive. Masters and slaves is used rotation method. EE-MAC uses some logics of PSM, like frequently waking up at the starting of the beacon interval.

Knowledge and guidance can provide for route lookup process by EE-MAC, because only master nodes can be selected along a routing path. When packet is coming up on that time EE-MAC requires a method to awaken a sleeping node. So it is regularly handled by native method at the MAC or physical layers. In EE-MAC, suppose node has been asleep than upcoming packets are not lost because there are some nearest upstream node is store them into buffer. When sleeping node awakens, the buffered packets are sent to it. [8]

B. CMAC

Convergent MAC is low duty-cycle MAC layer protocol. C MAC decrease latency and increase throughput. It use less number of duty cycle in MAC. CMAC use anycast and the forwarding nodes will be wake up. Then after it converges to unicast with synchronized scheduling from anycast with unsynchronized. Current duty cycling MAC layer protocols for wireless sensor networks are either synchronized using explicit schedule exchanges or totally unsynchronized. Now CMAC uses unsynchronized sleep scheduling like when there is no packet for transmission. While transmitting packets, CMAC first uses aggressive RTS to anycast which wake up first and detect the traffic using double channel check. Packet will be send when sender is able to transmit packets to a node with acceptable routing metric. CMAC converges from anycast forwarding to unicast to avoid the overhead of anycast.

In aggressive RTS the long preamble breaks up into RTS packets. They are separated by fixed short gaps each of which allows receivers to send back CTS packets. When transmitter receives it send a data packet. The number of packets to be sent in RTS depends on duty cycle length. If the nodes wakes up randomly then expected latency reduced by half. Here we use double channel check which assesses the channel twice with a short separation between them each time. If first check finds the channel busy then second channel will b cancelled. Here both the gap between two RTS and two channels is to be fixed. In synchronized schedule two nodes have to maintain the schedule as long as the traffic between them in the network. In anycast forwarding the neighbor nodes of the transmitter that are closer to the destination defined as a forwarding set. In CMAC, the CTS transmissions are prioritized according to the routing metrics of contending nodes. Nodes with better

Volume - 5 | Issue - 1 | Jan Special Issue - 2015 | ISSN - 2249-555X

routing metrics can send CTS packets earlier. Unicast is also used because of shortcomings of anycast.[9]

C. PARO

It is the Power Aware Routing Protocol proposed in[16]. The main goal of this protocol is to minimize the transmission power consumed in the network. Using PARO, one or more intermediate node elects to forward packets on behalf of source-destination pair for reducing the power in wireless communication.

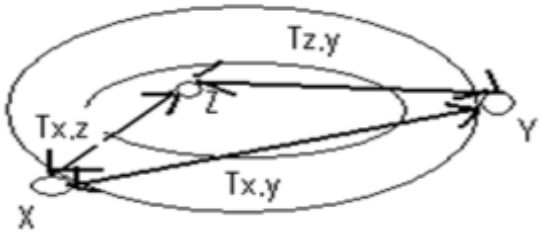


Fig.2 Transmission handle by PARO

In this Protocol if any node X want to communicate with the node Y. So transmission power neded for this is Tx,y. Suppose there is a another node Z, inter mediator of X and Y. So we calculate the power of Tx,z and Tz,y. If transmission

Power Tx,y > Tx,z + Tz,y then intermediate is used for the transmission of packets between X and Y. By using PARO sometimes we got several intermediate nodes in behalf of transmitted node. Due to this no of messges are sent by the source node using the multiple paths. But it represents the wastage of bandwidth and also the power resources. The redirect algorithm addresses th issues by giving the priority for the transmission of packets to that candidate which has the lowest route optimization value. PARO is based on principle that to add redirectors between souce node and destination node for reducing the transmission power to deliver the packets in ad hoc network. [10]

IV.CONCLUSION

In this paper we have carried survey of energy efficient routing protocol at MAC layer namely PCM, PCMA and PARO. All three are proposed for the energy saving, whenever source node want to transmit packets to the destination node. In this paper PCM is used for reducing transmission power periodically to save the energy level. As for the same PCMA is used to bound the range of transmitter, it uses the busy tone channel from active receivers node to say that currently channel is busy to transmitter. And the lastly PARO is used to find minimal redirect-route to save the power level. We could see from this study that power consumption in wireless network must be reduced to increase the lifetime of network transmission. It has also been observed that by implementing a proper standardized energy model, we can increase the ratio of successful transmission due to decrease the energy consumption in wireless network.

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