Energy-Consumption in MAC Layer Protocols in Ad Hoc Networks

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Abstract- *A mobile ad hoc network (MANET) is defined as an autonomous system of mobile routers (and their associated hosts) connected by wireless links the union of which forms an arbitrary graph. It is characterized by fast deployment, dynamic multi-hop topology, self-organization without typical infrastructure support, etc. These properties are desirable in situations such as battlefields, where network connectivity is temporarily needed, or fixed infrastructures are unavailable, expensive, or infeasible to deploy.Wireless networks can be classified in two types: First, infrastructure network which consists of a network with fixed and wired gateways. Second, infrastructure less (ad-hoc) networks. In ad-hoc networks all nodes are mobile and can be connected dynamically in an arbitrary manner. All nodes of these networks behave as routers and take part in discovery and maintenance of routes to other nodes in the network. Some challenges that ad-hoc networking faces are limited wireless transmission range, hidden terminal problems, packet losses due to transmission errors, mobility induced route changes, and battery constraints. Resources required during data transmission may not be available in large amount. This may interrupt overall working of network. Ad hoc mode is easily deployable. Network can be established any time any where. Popularity of such network is increasing day by day. Battery power is one of the main issues in working of Ad hoc mode. Overall working and lifetime of Ad hoc network is totally dependent on power available at a node. Power consumption in data transmission depends on distance between two nodes. Large distance may consume lot of battery power. Route selection, Network information distribution and retransmission of data also consumes noticeable amount of battery power. If a node spends very large part of its battery power in few data transmission then it may no longer be available to other nodes in the network. Such types of node are excluded from network path. In this paper it has been analyzed that data transmission depends on the routing protocol using which data transmitted. We work on different routing protocol and then last we work on MAC Layer of Network.*

I. INTRODUCTION

A mobile ad hoc network (MANET) is defined as an autonomous system of mobile routers (and their associated hosts) connected by wireless links the union of which forms an arbitrary graph. It is characterized by fast deployment, dynamic multi-hop topology, self-organization without typical infrastructure support, etc. These properties are desirable in situations such as battlefields, where network connectivity is temporarily needed, or fixed infrastructures are unavailable, expensive, or infeasible to deploy. To enhance the prediction of the best overall performance, a network layer metric has a better overview of the network.

Wide deployment of MANET has not come yet due to many technical challenges, among which energy issue is a fundamental one. Typical wireless devices are powered by small-sized batteries, whose replacement is very difficult or even impossible in some applications (e.g. disaster relief operation). Therefore, power conservation is one of the most important design considerations for MANET. It has attracted a large number of researchers in recent years. In this paper, we will focus on energy aware MAC (Media Access Control) layer protocols for ad hoc networks. MAC layer is the sublayer of the data link layer that is responsible for coordinating and scheduling of transmissions among competing nodes. As claimed by, MAC protocols could significantly reduce the power consumption of mobile terminals in MANETs. The energy-aware MAC protocols in a multi-hop self-organizing mobile ad hoc network must simultaneously satisfy the following three objectives. First, MAC protocols should facilitate the creation of the network infrastructure. Second, MAC protocols are in charge of fairly and efficiently sharing the wireless channels among a number of mobile terminals. In MAC layer channel scheduling, packet collision among different users should be reduced or even completely avoided, and the bandwidth

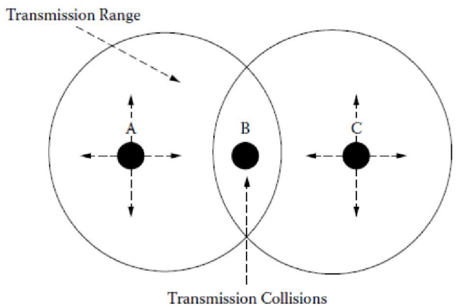


Fig 1.1 Hidden Nodes

should be fully-utilized. These two goals are confliicting with each other. Therefore MAC protocols should be carefully designed to balance them based on network requirements. Third, MAC protocols should be energy-aware for extending battery lifetime. Supporting power management to save energy is required for battery-powered mobile nodes in MANETs. Actually, this is the motivation of our paper. The power conservation mechanisms for MANETs also must support multi-hop forwarding. They should be distributed, as there is no centralized control to rely on.

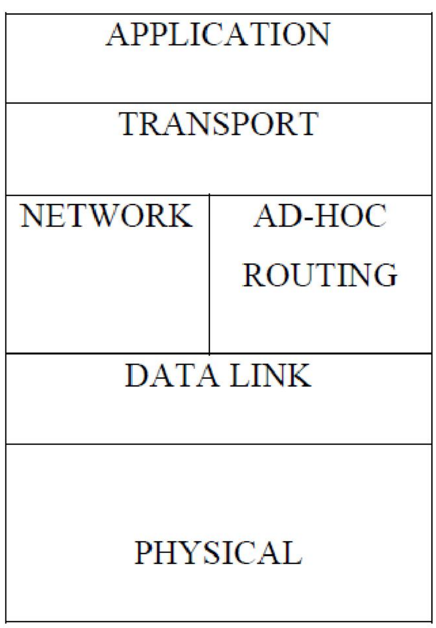


Fig.1.2 MANET Protocol Stack

As like wired TCP/IP protocol stack, wireless TCP/IP also have five layers. Main difference between two protocol stack lies in network layer shown in Fig.1.2. Mobile nodes use an ad-hoc routing protocol to route the packets. In this section the protocol stack for mobile ad-hoc networks is described. This gives a comprehensive picture of, and helps to better understand, mobile ad-hoc networks. It has similarities to the TCP/IP protocol suite. As can be seen the OSI layers for *session*, *presentation* and *application* are merged into one section, the application layer.

Table 1 Difference between Cellular and Adhoc Network

Cellular	Ad-Hoc Wireless Network
Infrastructure Networks	Infrastructure less networks
Fixed, prelocated cell sites and base station	No Base Station and rapid deployment
Static backbone Network Topology	Highly dynamic network topologies with Multihop
Relatively caring environment and stable connectivity	Hostile environment (noise, losses) and irregular connectivity
Detailed planning before base station can be installed	Ad-hoc network automatically forms and adapts to changes
High setup costs	Cost-effective
Large setup time	Less setup time

TCP Design Challenges And Issues In Wireless Ad-Hoc Network

1. Power Control

Power control in wireless network has recently received a lot of attention for two main reasons. First, power control has been shown to increase spatial channel reuse, hence increasing the overall channel utilization. This issue is particularly critical given the ever-increasing demand for channel bandwidth in wireless environments. Second, power control improves the overall energy consumption in a MANET, consequently prolonging the lifetime of the network. Portable devices are often powered by batteries with limited weight and lifetime and energy saving is a crucial factor that impacts the survivability of such devices. Energy is consumed in three ways. First, energy is consumed during the transmission of individual packets. Second, energy is consumed while forwarding those packets through the network. And finally, energy is consumed by nodes that are idle and not transmitting or forwarding packets. Power controlling can be done in various ways like Topology control, using common power for all nodes as well as using energy efficient routing. Power control is required to make network lifetime long. First of all, the sender can save its own energy by reducing transmission power, as energy consumption in transmitting mode is proportional to the transmission power. Then, there are two types of unnecessary energy consumption. One is retransmitting packets and one is receiving undesired packets. Power control algorithms target for high network throughput, lower energy consumption, good fairness, low packet latency and etc. It may not be possible for one power control algorithm to reach all targets because each target may conflict with each other. Power saving mode and energy efficient protocols can be implemented to reduce energy consumption in wireless ad-hoc network.

2. Energy Consumption

Ad-hoc networks enable users to spontaneously form a dynamic communication system. They allow users to access the services offered by the fixed network through multihop communications, without requiring infrastructure in the user proximity. However, to offer high-quality and low-cost services to Ad-hoc network nodes, several technical challenges still need to be addressed. First, wireless networks are plagued by scarcity of communication bandwidth; therefore, a key issue is to satisfy user requests with minimum service delay. Second, because network nodes have limited energy resources, the energy expended for transferring information across the network has to be minimized. Ad-hoc wireless networks are constrained by limited battery power, which makes energy management an important issue.

The wireless channel is characterized by signal strength attenuating with distance from the transmitter. Nodes can correctly receive a packet if the signal strength of the packet at the node is above a certain threshold called Receive Threshold. If the distance between transmitter and receiver is such that the signal strength is above this threshold, the receiver is called in transmission range of the sender[16]. There is a lower threshold called Carrier Sense Threshold, up to which the received signal strength is enough for the receiver to detect the packet sent, but the receiver it correctly. All received signals that falls between these thresholds cause the channel to be sensed busy and contribute to the interference at the receiver. Another important parameter in wireless network is the Signal to Interference Ratio. This parameter gives the ratio of the received signal to that of the co-channel and adjacent channel interference.

2.1 Measurement Of Energy Consumption

Since energy is a scarce and non-renewable resource in wireless ad-hoc networks, energy efficient protocol design is a key concern. Four possible energy consumption states are identified. Transmit, receive, idle and sleep. The first two states are when the node is transmitting and receiving packets respectively. Idle state is when node is waiting for any packet and is continuously sensing the medium and the sleep state is a very low power state where the node can neither transmit or receive. The cost associated with each packet at a 21 node is represented as the total of incremental cost *m* proportional to the packet *size* and a fixed cost *b* associated with channel acquisition.

$$Cost = m \times size + b$$

$$Cost_{broadcast} = m_{send} \times size + b_{send} + \sum_{n \in S} (m_{recv} \times size + b_{recv})$$

Where

S = set of nodes within transmission range of transmitter node
m send,b send = incremental and fixed cost for sending the broadcast packet,
m recv, b recv = incremental and fixed cost for receiving the broadcast packet.

2.2 Calculation Of Energy Required For Transmission And Reception Of a Single Packet

- For Data Packets

Packet length = 1500bytes,

Bit rate = 250kbps (48ms/packet or 20.8 packets/se)

Total packet size = size of (preamble + PLCP header + MAC header + IP header + Data)
= (144 + 48 + 28 × 8+20 × 8 + 1500 × 8) bits (default values, as as used in NS-2).

Although, the preamble and PLCP header are transmitted at 1Mbps while the rest are sent at 11Mbps. Thus, we have 144+48bits sent at 1Mbps, with a transmission time for single packet 0.19ms.

With 8 × 1548 bits sent at 11Mbps, the transmission time for a single packet is 1.128ms. Hence the total transmission time for a single packet is 1.128+0.19 = 1.318ms.

- For Ack packets

Packet length = 14bytes,
Bit rate = 250kbps,

Total packet size = size of (preamble + PLCP header + ACK)
= (144 + 48 + 14 × 8) bits

So, transmission time for a single packet is 0.304ms

- Calculation Of Energy Spent

The transmission and reception cost for a packet can be calculated like this for a particular packet. For an example if the transmission and reception power are taken 1.3mW and 0.9mW respectively then various energy components are

E Tpck = 1.3 × 1.318 × 10−3 =1.713mW
E Rpck = 0.9 × 1.318 × 10−3 =1.186mW
E Tack = 1.3 × 304 × 10−6 =0.395mW
E Rack = 0.9 × 304 × 10−6 =0.274mW

Thus energy calculation can be done using the equations.

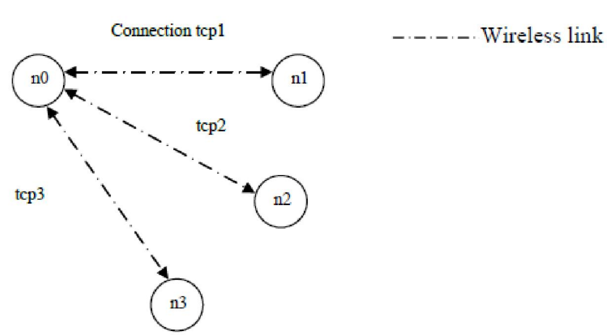
Energy consumption is not an issue of a single layer. Different layer protocols affect energy in various ways. The effect of different layers is described further.

III. EVALUATION OF ENERGY CONSUMPTION

Energy conservation in an ad-hoc network is the procedure of determining the transmit power of each communication terminal. It is calculated at each and every node in wireless network which is either transmitting or receiving any packet. Energy consumption at mac layer is also considerable.

3.1 SIMULATION SCENARIO

Simple topology with 4 nodes is used. Each node is connected to other by wireless link. A simple MANET example script available in ns-2.30/tcl/ex is used as a base script. The node movement patterns are generated by giving commands as given in script. A node is situated at random position at the start of simulation and moves toward random destination in the script with random velocity as specified in command. The traffic is generated manually using commands in script. We have used ftp as TCP traffic.



We have established three TCP connections, tcp1, tcp2, and tcp3. We have configured Energy Model which is implemented in *ns*, is a node attribute. The energy model represents level of energy in a mobile host[10]. The energy model in a node has an initial value which is the level of energy the node has at the beginning of the simulation. This is known as initialEnergy_. It also has a given energy usage for every packet it transmits and receives. These are called txPower_ and rxPower_. Timings for traffic are given below.

ftp1 – 1s to 38 s ftp2 – 1s to 38 s ftp3 – 1 s to 38 s

Each and every node consumes energy in transmitting DATA packets, CONTROL packets and ACK packets.

Reactive routing is also known as on-demand routing. These protocols take a lazy approach to routing. They do not maintain or constantly update their route tables with the latest route topology. Examples of reactive routing protocols are the dynamic source Routing (DSR), ad-hoc on-demand distance vector routing (AODV) and temporally ordered routing algorithm (TORA). DSR is one of the more generally accepted reactive routing protocols. In DSR, when a node wishes to establish a route, it issues a route request (RREQ) to all of its neighbors. Each neighbor broadcasts this RREQ, adding its own address in the header of the packet. When the RREQ is received by the destination or by a node with a route to the destination, a route reply (RREP) is generated and sent back to the sender along with the addresses accumulated in the RREQ header. Since this process may consume a lot of bandwidth, DSR provides each node with a route cache to be used aggressively to reduce the number of control messages that must be sent. If a node has a cache entry for the destination, when a route request for that destination is received at the node, it will use the cached copy rather than forwarding the request to the network. In addition, each node promiscuously listens to other control messages (RREQs and RREPs) for additional routing data to add to its cache.

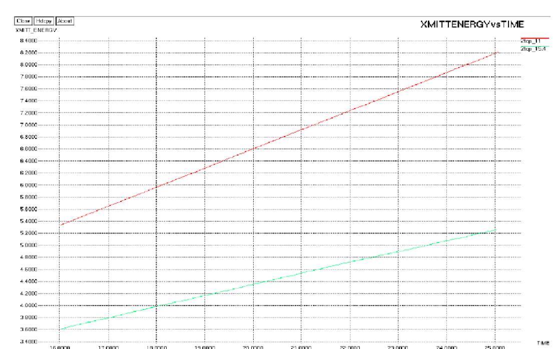


Fig 3.2 Comparison for node 2 with MAC standards 802.11 and 802.15.4

3.2 ANALYSIS OF ENERGY CONSUMPTION BASED ON MAC STANDARDS

A mobile ad-hoc network (MANET) is defined as an autonomous system of mobile routers connected by wireless links the union of which forms an arbitrary graph. It is characterized by fast deployment, dynamic multi-hop topology, self-organization without typical infrastructure support, etc. These properties are desirable in situations such as battlefields, where network connectivity is temporarily needed, or fixed infrastructures are unavailable, expensive, or infeasible to deploy. Power conservation in an ad-hoc network is the procedure of determining the transmit power of each communication terminal such that a design objective can be satisfied. There are two major reasons for transmit power control. First, transmitting at a high power may increase the interference to co-existing users and therefore degrade network throughput. Power saving mechanisms have been shown to be able to decrease multi-user interference, and hence increase spatial channel reuse and the number of simultaneous single-hop transmissions. One direct benefit of this increase is the enlarged overall traffic carrying capacity of the network. Second, energy-efficient schemes can impact battery life, consequently prolonging the lifetime of the network. Current power control mechanisms include low-power wireless access protocols, power-aware routing for ad-hoc network and node-level energy-efficient information processing.

MAC layer is the sub layer of the data link layer that is responsible for coordinating and scheduling of transmissions among competing nodes. As claimed by, MAC protocols could significantly reduce the power consumption of mobile terminals in MANETs. The energy-aware MAC protocols in a multi-hop self-organizing mobile ad-hoc network must simultaneously satisfy the following three objectives. First, MAC protocols should facilitate the creation of the network infrastructure. Second, MAC protocols are in charge of fairly and efficiently sharing the wireless channels among a number of mobile terminals. In MAC layer channel scheduling, packet collision among different users should be reduced or even completely avoided, and the bandwidth should be fully-utilized. These two goals are conflicting with each other. Therefore MAC protocols should be carefully designed to balance them based on network requirements. Third, MAC protocols should be energy-aware for extending battery lifetime. Supporting power management to save energy is 31 required for battery-powered mobile nodes in MANETs. Actually, this is the motivation of our paper. The power conservation mechanisms for MANETs also must support multi-hop forwarding. They should be distributed, as there is no centralized control to rely on. MAC protocols play significant role in determining the efficiency of wireless channel bandwidth sharing and energy cost of communication.

IV. PROPOSED SOLUTION

The limited energy capacity of mobile computing devices has brought energy conservation to the forefront of concerns for enabling mobile communications. This is a particular concern for mobile ad hoc networks where devices are expected to be deployed for long periods of time with limited potential for recharging batteries. Such expectations demand the conservation of energy in all components of the mobile device to support improvements in device lifetime. In wireless networks, there is a direct tradeoff between the amount of data an application sends and the amount of energy consumed by sending that data. Application-level techniques can be used to reduce the amount of data to send, and so the amount of energy consumed. However, once the application decides to send some data, it is up to the network to try to deliver it in an energy-efficient manner. To support energy-efficient communication in ad hoc networks, it is necessary to consider energy consumption at multiple layers in the network protocol stack[2]. At the network layer, intelligent routing protocols can minimize overhead and ensure the use of minimum energy routes. At the medium access control (MAC) layer, techniques can be used to reduce the energy consumed during data transmission and reception. Additionally, an intelligent MAC protocol can turn off the wireless communication device when the node is idle. Communication in ad hoc networks necessarily drains the batteries of the participating nodes, and eventually results in the failure of nodes due to lack of energy. Since the goal of an ad hoc network is to support some desired communication, energy conservation techniques must consider the impact of specific node failures on effective communication in the network.

V. CONCLUSION

Energy consumption is most significant part in network lifetime. So It is most important to study how to reduce the power consumption while at the same time fully-utilize the bandwidth resource. By making the physical interface aware of the mac activity power consumption can be reduced. We consume energy when the event of packet (data) sending and receiving. So we improve energy consumption with all using network resources.

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