Optimizing Operational Lifetime in Manet by Network Topology Control Mechanism

Khaja Mahabubullah, Syed Abdul Sattar

Abstract- Recent developments in mobile networks have gained much importance because of their improved edibility and reduced costs. In addition to device portability MANET does not require a pre-established network arrangement and hence can be easily install in conditions like emergency rescue and disaster management but there are someproblemswhich are inherent to MANET such as hidden and exposed terminal problems. Routing in this kind of network is much more challenging than in conventional network because of their limited bandwidth, limited processing power and restricted hardware resources. More important the Nodes in MANET are mostly operated by battery and the batteries are limited in capacity and sometime it is midcult to replacer re-charge the battery and this reduces the network lifetime. To enhance the operational lifetime of Adhoc network the nodes in the network should use the minimal power during communication and some beneficial energy saving skills must be applied at the hardware level as well as protocol level. In this paper, we have focused our concern on energy conservation technique and proposed a topology control mechanism to enhance the operational life time in MANET our method will consume considerably least possible power while transmitting the packet from source to destination.

Keywords— MANET, NODE, PACKET, PLR, LFTC, COMPOW, LEAR, DEAR, PARO, SPAN.

I. INTRODUCTION

Because of latest advancement in wireless communication technologies and availability of less expensive hardware resourceshasbeen given much attention in mobile computing and its applications. A mobile ad hoc network is an independent system of mobile nodes connected by wireless links and nodes are free to move and organize themselvesrandomlyand the topology changes promptly and unpredictably(Figure 1.1). Such a network may operate in a standalone manner and aprimarytask is safeguard route availability while sustaining lesser control overhead. In MANET the nodes generate the packet and as a router they forward the packet and it gets transmitted from source to destination in multi-hops [1]. The Applications depends on the electiveness of routing protocol and Nodes are powered by electro-chemical batteries whose capacities are limited and Servicing or replacing these batteries are not possible at many places.

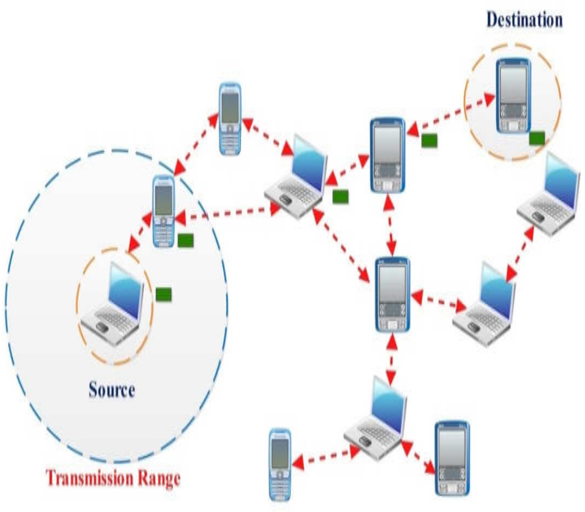

Fig. 1.1 Routing in Mobile Adhoc Network

Therefore to enhance thenetwork lifetimein MANET some power saving mechanism must be developed. Computationand communication are the two main sources ofpower consumption and the most energy consuming activity isthe communication so proper power management approachesduring transmission andreception will enhance the network lifetime. The transmission power isdirectly proportional to energy consumption at the node. Transmissionpower also determines the range over which a node can communicate with the neighbour. Energy efficiency in MANET is addressed at the hardware level and protocol level [2] hence energy aware routing protocols have been proposed to overcome the over-utilization of power and to conserve the energythe nodes in idle state are put to sleep state. Lifetime of MANET can be enhanced if transmission power is adjusted to a lower level.

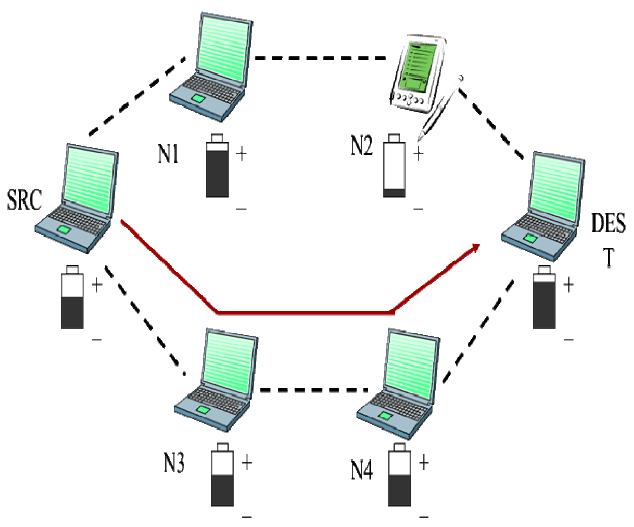

Fig 1.2 Power Aware Routing in Mobile Adhoc Network

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II. Related Work

Topology of MANET is affected by many features like node mobility, weather conditions and environmental intervention and fewadaptablefactors like transmission power, antenna direction and duty-cycle scheduling [3]. Nodes have impulsive flexibility due to which the wireless network experiences prompt variations.In dense network many links leads to high energy consumption. By modifying network topologythe performance metrics such as network lifetime and throughput isimprovedand the interference is reduced by varying the transmission range of nodes to near oneand more data transmission is carried out simultaneously in neighbourhood of a node.The topology control is an effective power savingtechnique and if a network has bad topology then there areadverse effect such as low capacity, high end-to-end delay and weak robustness to node failure [4].Some significant work has been done to achieve energy efficiency and different techniques and various protocols had been proposed to improve the performanceby many researchers and some of them are explained below. Power aware Localized Routing Protocol (PLR) [5] assumed that the source node has location information ofall nodes and destination node and this will find the link cost between its neighbours anddestination,the node withlowest link cost is selected as nexthop and the sameprocedure is repeated for the intermediate nodes till the destinationnode is reached whereas the location free topology control protocol (LFTC) Protocol constructs power-efficient network topologywhichavoids any potential collision due to hidden terminal problem [6]. It works in two phasesin first phase i.e. Link determination phase a node selectsa set of its neighbours where each node adjusts its transmission power to a minimum value to communicate with its neighbours.In second phase i.e. Interference announcement phasewhich avoidsthe data collision by using appropriate transmission power control.

The Common Power (COMPOW) Protocol [7] finds the common transmission power between two nodesto maintain bi-directionality amongthe pair of communicating nodes. If common transmission power value is very lowthan a node is reachable to asection of nodes and if this value is very high a node is able to reach directly to all other nodes whichresults in high energy consumption. Therefore the common transmission value must be leastenough to preserves connectivity of a network is.The major drawback of COMPOW is its significant message overhead. It also tendsto use higher power if nodes are unevenly distributed.

Localized Energy Aware Routing (LEAR) Protocol [8] modifies the route discovery procedure of DSR protocol for balancing the powerdepletion. In DSR each node appends its identity tothe header of route request message and forwards it to its destination. Intermediatenodes participate in the path finding procedure. In LEARthe node forward the route-request messages to its neighbourifresidual energy value is higher than the threshold value otherwise it drops the messages and donot participatein route finding process and then the destination node receive route request from nodeshaving higher battery level.

In case of Device and Energy Aware Routing (DEAR) [9] a node is assumed to be device aware if it is powered by internal battery and external power source. It is supposedthat the cost of a nodepowered by an external source is zero hence the packets can be redirected to the powerednodes for savingthe power. An externally powered node has rich resources ofpower and it is capable toincrease its transmission power to a higher level and it iseasily reachable to any desired node in the network by one hop distance. DEAR providespower saving by eliminating a number of hops which increases the system lifetimeand average delay in packet receiving isalso minimized.

Power Aware Routing Optimization protocol (PARO) [10] assumes that each radio is dynamicallyadjusting its transmission power on per packet basis instead of broadcast method it supports node-to-node based approach to select the route which itemphases to minimize the transmission power to forward the packetsfrom source to destination. In network all the nodes are located within the maximumtransmission range with respect to each other. In packet forwarding technique one or more nodesare electedas the redirectorsin place of source destination pair to forward the packetswith reduced transmission power in this way they decreases the overall transmissionpower to deliver packets in networkthereby increasing the operational lifetime of network.

In MANET if a node is in low power state it is desirable to put the nodein sleep mode to save energy and to decide which node to put into sleep mode and whichin active mode a master node is selected to maintain the network connectivity SPANprotocol [11] employs a distributed approach to select a master node. The rule isthat if two of its neighbours cannot reach directly or via one or twomasters it should become a master. This rule does not yield the minimum numberof master nodes but it deliversstrong connectivity with considerable energy savings.However the master nodes are easily overloaded. Tominimize the overloading withdraw the master nodeat any time and its neighbour becomes amaster node if eligible.

III. Energy Consumption by nodes in an Ad Hoc Network

In Adhoc network energy consumption and bandwidth utilization are not identical. It is necessary to consider the cost of transmitting a packet,receiving a packet and even fordiscarding a packet. Protocol designers must therefore consider the magnitudes of broadcast and point-to-point traffic used by the protocol. Because channel acquisition overhead is moreand the small packets have unreasonably high energy costs and uncontrolled mode operation which is irrelevant to bandwidth utilization also attempts some energy cost [12].The relationship between transmit speed and overall energy consumption is complex and reduced data transmit time and receive time have only partial impact on per-packet energy consumption. Adhoc network does not use any base station infrastructure and the nodes communicate directly with all other nodes which are in wireless transmission range. hence the hosts must always be ready to receive traffic from their neighbours. A network interface operating in Adhoc mode does not sleep and it has a constant idle power consumption which reflects the cost of listening to the wireless channel [13]. This cost which has been measured is slightly less than the cost of the receiving traffic. In the simple case the energy consumed by the network interface when a host sends, receives or discard a packet can be described using a linear equation

$$\text{Energy} = m * \text{size} + b \qquad (1)$$

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3.1 Energy consumption of Nodes in Different Modes

As per the communication takes place the node undergoes transition from one state to another It is observed that the mobile node consume least power in sleep state as compared to other state [14]. Since the battery resource is limited so it misadvised to put the node in sleep state when it is not in use and the energy consumption of nodes in different modes can be represented as follows

$$E_{total}=E_{path-discovery}+E_{packet-transmission} \quad (1.1)$$

$$E_{path-discovery} \propto \text{control packets}$$

$$E_{packet-transmission} = E_{idle} + E_{active} + E_{sleep} + E_{transient} \quad (1.2)$$

$$E_{active} = E_{recv} + E_{transmit}$$

$$E_{sleep} \cong 0 \quad (1.3)$$

3.2 Power consumption in Transmission mode

In transmission mode the node sends data packet to other node in a network. The energy required to transmit the data packet is Transmission Energy which depends on size of data packet. The transmission energy is expressed as

$$E_{Transmit}= (330\times P_{length})/\, 2\times10^{6} \quad (1.4)$$

$$P_T = E_{Transmit}/T_t \quad (1.5)$$

Where $E_{transmit}$ is the transmission energy, P_T is Transmission Power, T_t is time taken to transmit data packet and P_{length} is length of data packet.

3.3 Power consumption in Reception mode

In reception mode the node receives the data packet from other node and the energyrequired to receive data packet is called Reception Energy. The reception energy isgiven as

$$E_{recv}= (330\times P_{length}) \,/\, 2\times10^{6} \quad (1.6)$$

$$P_R = E_{recv}/T_r \quad (1.7)$$

Where E_{recv} is reception energy, P_R is Reception Power and T_r is time taken to receive data packet and P_{length} is length of data packet.

3.4 Power consumption in idle mode

In the idle mode a node neither transmits nor receives data packet. But it consumes power pointlessly by listening to the wireless medium constantlytosense a packetwhich it should receive. In idle mode a node does not implicate in any data communicationprocess still it consumes a significant amount of energy which is same as theamount of energy consumed in reception mode. The power consumed in idle mode is

$$P_I = P_R \quad (1.8)$$

Where P_I is power consumed in idle mode and P_R is power consumed in reception mode.

3.5 Power consumption in Overhearing mode

In this mode a node listens to the data packet which is not destined for it. Theenergy consumed in this mode is similar as reception mode. Needlessly it consumesenergy in receiving such packets. The Power consumed in overhearing mode is

$$P_{Over} = P_R \quad (1.9)$$

Where P_{Over} is power consumed in overhearing mode and P_R is power consumed inreception mode.To maximize the network lifetime several power management techniques have been proposed to improve energy efficiency. A few of such schemes are described briefly inthe next section.

IV. Topology Control Mechanism

Due to flexibility of nodes the topology of MANET changes dynamically. Topology control is the art of coordinating nodes decision regarding their transmission ranges in order to generate a network with the desired properties such as reduction of node's transmission energy and enhancement of network capacity [15]. The topology control process consists of three differentphases. First phase is known as Initialization phase in which nodes use their maximum transmission power to layout the network topology and second phase is called Topology Construction phase which constructs the reduced network topology and the third is called topology maintenance phase in which the status of the reduced topology is monitored and new topology construction phase is initiated whenever it is required and this cycle is repeated and the Lifetime of MANET can be enhanced if transmission power is adjusted to reduced level. Topology control is one of the imperative practice for saving energy in wireless Adhoc networks the main goal in writing the topology control algorithms is to replace the long distance communication hops with smaller energy ancient hops such thatthe resulting topology retained its connectivity.

V. Proposed Topology Control Mechanism to Conserve Energy

Our proposed topology control mechanism to conserve energy in MANET works with the following assumptions.
(1) The topology has a symmetric communication.
(2) Nodes are similar and have equal computing ability and initial battery power.
(3) Nodes are equipped with GPS, so that they can acquire their locational information.
(4) Radio intervention at each node should be able to compute their received signal strength.
(5) The maximum transmission power P_{max} of all nodes isequal.

In our method at an initial stage a node say u determines its neighbours according to a power efficient topology control method. These neighbouring nodes are called direct communication set of node usay S (u). Then data packet transmission power of node u is calculatedsay P(u) which is the minimal power required to communicate with all its neighbours in the set S(u). And at a final stage a node determines the next hop node on the path to the destination. The node which is geographically closer to the destination is chosen as next hop on the path to the destination. All the other nodes in the direct communication set S (u) are put to sleep state to conserve energy. Our calculation can be represented mathematically as follows.

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Let P_{uv}represents the minimum power required for node u to communicate directly with node v. P_{uv} is computed and represented as

$$P_{uv} = P_{max} * P_{min}/P_r \quad (2)$$

$$P_r = P_t(\lambda / 4\pi d)^n g_t * g_r \quad (2.1)$$

Where P_{max} is the maximum transmission power of a node v, P_{min} is the smaller possible receiving power of node u, P_t and $R_e$present the signal power at transmitting and receiving antenna respectively indicates the carrier wavelength and d denotes the distance between the sender and the receiver, g_t and g_r denote the antenna gains at the sending and receivingnodes respectively since we assumed a symmetric communicationtherefore we conclude

$$C(P_{uv}) = C(P_{vu}) \quad (2.2)$$

WhereC (P_{uv}) denote the cost associated withsending a packet from node u to v.

VI. Conclusion

Network topology control mechanism is based on topology control method in which the network topology ismodified by adjusting the node's transmission power. A node that is geographically closer to the destination is selected as the next-hop for routing the traffic. The nodes which are not involved in on-going transmission are put to sleep state toconserveenergy. Energy saving at routing protocols level is much easier as compared to energy saving at mobile nodes. if we use different techniques in a combined manner it saves lot of energy and increase the lifetime of network

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