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Pragmatic Analysis of Energy Conservation in MANETs

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Abstract: Mobile ad hoc network (MANETs) is a collection of mobile nodes in which all the nodes are connected via wireless link. These are self configured networks. MANETs contains several characteristics. Because of these intrinsic properties, MANETs becomes special amongst the users. Nodes in MANETs perform in open media that permits the network to work without preinstalled infrastructure. These give tremendous flexibilities to MANETs. Since the nodes in MANETs are wireless and mobile at the same time, so these are dependent on battery or any exhaustible power device. All activities including computation, packet forwarding etc. are always associated with energy conservation. Due to lack of sufficient battery backup, nodes may show vulnerabilities. In this paper, it is approached to discuss the different factors concerning the energy consumption. Also simulation results are shown using NS 2 simulator.

Keywords: MANETs, wireless link, open media, dynamic topology, energy conservation

I. INTRODUCTION

Mobile Adhoc Network (MANETs) is an open, dynamic, multi hop, self-organizing, infrastructure less network in which mobile nodes communicate with each other in wireless link [1]. These intrinsic characteristics of MANETs give tremendous flexibility to MANETs users. These are suitable for mission critic areas like military operation, disaster prone areas, outdoor activities, peer-to-peer game etc. Being a multi-hop network, any node under active route works as mobile router that transmit, receive or forward packets. Performance of MANETs solely depends on the cooperation of mobile nodes[11] . Mobile nodes are basically battery operated. So, energy conservation of nodes becomes a challenging and critical issue in current scenario. Energy conservation of nodes in MANETs should be modeled and analysed [2]. It is very important to conserve energy. In mission critic operations, energy conservation plays even more important role which is critical to the success of the tasks performed by the network [3]. In order to facilitate communication in MANETs, routing of packet is must. By this, it tries to discover route and communicate to each other. In this scenario, along with a good energy conservation model, an efficient routing protocol is also expected which will spend optimum energy while discovering route [4][5][6]. Energy of node is mainly consumed by central processing unit and radio (transmitter/receiver) [4]. A mobile node consumes highest energy while transmitting and receiving packets. Still some energy are consumed while it is in idle and listening to the wireless medium for any possible communication requests from other nodes. An energy efficient routing protocol may reduce the consumption of more energy.

In [5], author mentioned that some of energy are consumed while listening to other. Of course, improved design efficiency and better user interface along with memory devices helps to reduce energy consumption. Energy consumed by transceiver is also very significant [5].

Even, evaluating the energy consumption of network protocols requires an approximation between a precise estimate of energy consumption and high-level insight into protocol behavior [6]. Problem of power level extensively effect the performance of routing protocol. Even rapidly changing traffic pattern also effect the energy level of nodes [8]. Overall performance of MANETs depends on node cooperation. Again node cooperation depends on its energy level. So, it becomes a challenging issue for the MANETs user to propose a system through which it can save energy.

II. LITERATURE REVIEW

Energy conservation model is one of the most important point to be considered. Though wireless connectivity as well as node mobility gives tremendous amount of flexibility to MANETs, yet it generates several problems including power conservation of mobile node. Operational life of mobile nodes are totally dependent on battery power of individual nodes. Every action of mobile nodes depends on power of nodes. Each layer consumes some power while any of the activities happened in MANETs. Protocols are concerned with power consumption mode of operation.

As mentioned in [16], the generic model to calculate power consumption is that,

Energy required to transmit a packet is given as follows:

$E(p) = i * v * t$ Joules, where i is the current, v is the voltage which is equivalent to 5V and t is the time required to transmit the packet.

$t = (p_h/(6 * 10^6)) + (p_d/(54 * 10^6))$ sec , where p_h and p_d are packet header and packet data size respectively in bits. Transmission and receiving energy can also be represented as follows:

Transmission energy E_t=280 mA * v * t_t

Receiving energy E_r= 240 mA * v * t_r where v is the voltage, t_t is the transmission time and t_r is the receiving time. Energy spends on idle time which is actually same as receiving energy can be represented as follows:

E_{idle}= 240 mA * v * t_i where t_i is the NIC idle time. Some of energy is also consumed due to packet overhearing i.e. E_o. So, total energy consumed at a node is denoted by,

$$E = E_t + E_r + E_o$$

In [7], Routing itself consumes energy of various nodes including middle hop. While transmitting beaconing signal to neighboring nodes, it consumes energy [7]. While source node use some middle hop to transfer the packets to destination, it consumes more energy as to forward the packets, middle hop will have to be active all the time [7]. In this case, routing protocol will have to be more conscious for conserving node's residual energy.

To conserve energy efficiently, author considers a new parameter which is named as energy distance factor that helps to select the best next hop node for optimizing the energy efficiency of the network. By considering residual energy of a node instead of absolute energy of the node, the proposed routing protocol tries to optimize the use of energy. It helps to select the best node in terms of energy. If a node becomes out of energy during communication, a new route discovery process must start. That consumes more energy as well as generates more transmission delay. Hence to avoid that an energy aware routing protocol has been proposed in the paper.

In [9], this paper authors proposed a new routing protocol that dealt with both MAC layer and network layer. The proposed algorithm also considers the dynamic adjustment of transmission power of nodes and also considers the residual energy of the nodes for balancing the traffic. For this, source will have to select one of the route as optimum route for data transmission based on energy conservation logic. Here, it is considered that a mobile node may have two modes either in active mode (AM) or in power save mode (PS). In AM, a node is active all the time whereas in PS, a mode is in sleeping mode most of time but periodically checking whether there is any pending message or not. Transitions between PS and AM are initiated by packet arrivals and expiration of the keep alive timer. Sub-state transitions inside PS or AM are controlled by the IEEE 802.11 MAC protocol. In this methodology, time is divided into beacon interval. There is an Ad hoc traffic indication message (ATIM) at the beginning of each beacon time interval. Befor starting actual transmission, source sends an ATIM frame to destination. As and when it gets acknowledgement then only it starts actual communication. Otherwise, nodes are in PS mode. To enhance the performance of energy saving, later on New Power Saving Mode (NPSM) has been proposed. Each node maintains a neighbor list that caches a neighbor's mode and a time-stamp of the most recent update from this neighbor. Neighbor's power mode is achieved by two ways; by explicit local HELLO message or by passive inference. Based on this authors proposed a routing algorithm that considered form a cross layer design involving MAC layer and network layer.

In [13], energy model has been extended to calculate the energy that is spent during data flow. Transmission and reception cost are calculated for a node if a node belongs to a flow. Otherwise only reception cost is calculated if it near a flow. Collision due to flow are measured and these are used to evaluate the effect of such interference in the energy consumption. Based on this condition author tried to calculate extra energy spent due to collision.

Energy consumption states are divided into four different types such as transmit, receive, idle and sleep. When data transmission is held then both transmission and receive power are spent. But in idle state, node is waiting for packet transfer. In sleep mode, node is totally unaware about data transmission and very low powered state. The cost associated with each packet at a node is represented as the total of incremental cost *m* proportional to the packet *size* and a fixed cost *b* associated with channel acquisition,

$$Cost = m * size + b$$

Based on the above concept, a new model is proposed to calculate the energy spent at each node due to data flow. It also considers the total energy consumed due to some other nodes, which consists of energy spent for transmission of acknowledgement, energy spent for transmission of data packet, energy spent for reception of acknowledgement, energy spent for reception data packet

III. Simulation and Analysis of Results

Effect of energy consumption in MANETs by node mobility, traffic load, network size and pause time for the protocol AODV are shown below. NS 2 (Network Simulator version 2) is used for simulation purpose. Simulation environment is considered as shown in Table 1.

Simulation Parameters

Animation area	1000m X 1000m
Mobility model	Random way point (RWP)
Channel type	Wireless
No. of nodes	100

Simulation time	600 sec
Pause time	10-70 sec
Node Speed	10-70 m/s
Traffic rate	100 kbs-1200kbs
Transmission range	100 m
Packet size	512 byte
Traffic type	CBR
Routing protocol	AODV
Initial Energy	100 Joule
Idle Power	1.0w
Receiving Power	1.1w
Transmission Power	1.65 w
Transition Power	0.6w
Sleep Power	0.001w
Transition time	0.005s

Table 1

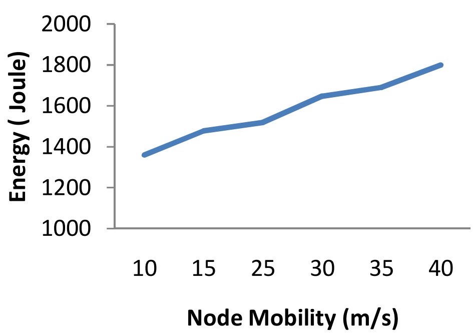

Fig 1. Energy consumption vs. node mobility

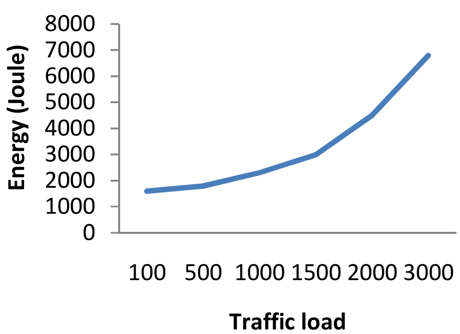

Fig 2. Energy consumption vs. traffic load

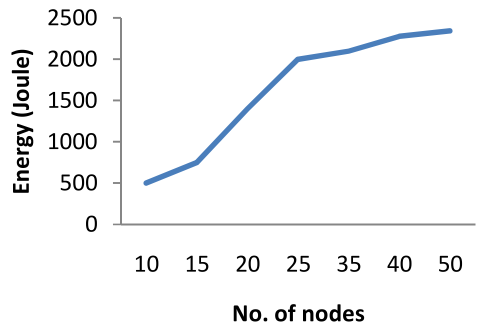

Fig 3. Energy consumption vs. number of nodes

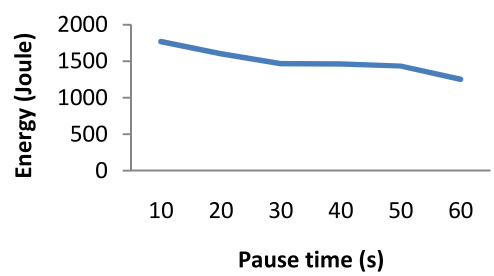

Fig 4. Energy consumption vs. pause time

Node mobility is a factor that affects the energy consumption. In Figure 1, energy consumption increases with increased node mobility. In high node mobility, these are in transit state, they lose connectivity frequently. Probability for a path break is more and services tend to be available for a shorter period. Due to non linked path, packets are dropped frequently. Some packets will be lost due to collision resultant from high mobility. Routing protocol will have to take care of all these. As a results, it will have to consume more energy. That is reflected in the Figure 1. Similarly in Figure 2, it shows the effect of traffic load in energy consumption. As the traffic load is getting more, nodes will have to engage themselves with various activities including packet forwarding, computation etc. As a result, limited energy stack in nodes will be degrading. In Figure 3, it is observed that scalability of the network is another factor for high power consumption. Due to bigger network, more control as well as data packets will be generated which may increase node activities more. This finally results in more energy consumption. On the other hand for a stable network energy consumption is not drastically increasing. It maintains a level. It is reflected in Figure 4 as the pause time is increasing, network becomes more stable, energy consumption in the network is also not in increasing order as it found in previous cases. High pause time implies more stable network that leads to long lived service and stable network

IV. CONCLUSION

Energy consumption is a critical issue in MANETs as the nodes are powered by limited energy source such as battery power. MANETs is very scalable. Energy consumption in MANETs is affected by node mobility, traffic load, network size and pause time etc. The frequently changing traffic pattern, the mobility of the nodes and the lack of fixed infrastructure makes routing in a MANETs a challenging issue. In this paper, various simulation results are shown. Affect of energy consumption by different factors such as node mobility, traffic load, pause time, network scalability etc. are explained with the help of simulation results and analysis. Proposing an QoS aware routing protocol which will also be an energy efficient process, is left as a future work.

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