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A Complete Study on Energy Efficient Techniques for Mobile Adhoc Networks

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Abstract- The process of wireless networks in the applications like transferring video files is subjected to dual constraints. Both minimization of power and other QoS requirements like delay, throughputs are have to be take care properly. Mobile Ad Hoc Networks are more perceptive to these issues where each mobile device is active like a router and consequently, routing delay adds considerably to overall end-to-end delay. This paper presents a survey on power efficient routing protocols for Mobile Ad-Hoc Networks. This survey centered on recent progress on power saving algorithms. In addition we suggest one power aware technique which will reduce power consumption as well as increase the lifetime of node and network.

Keywords: **Mobile adhoc networks, Quality of Services, Minimum Power consumption, Network life time.**

1. Introduction

The Mobile ad hoc network [MANET] is a distributed network where mobile nodes are connected together by wireless links without any fixed infrastructure like base stations, fixed links, routers, centralized servers. In such a network the data can be transmitted or routed by intermediate nodes which are not in the fixed location. A large scale of independence and self organizing capability formulate it completely different from other networks. The topology of mobile Ad Hoc network is not static and depends upon the mobility of the nodes so it can adjust rapidly and suddenly. Mobile Ad Hoc networks are useful in many areas such as, vehicular network, Communication in front line, Disaster recovery areas, agro sensing, Institutions and Colleges, Space and astronomy related projects, pollution monitoring and Medical Field[1].

Mobile Ad Hoc networks have few challenges like Limited wireless transmission range, broadcast nature of the wireless medium, hidden terminal and exposed terminal problems, packet losses due to transmission errors and mobility, stimulated change of route, Battery constraints and security problem [2, 3].

The power level basically affects many features of the operation in the network including the throughput of the network. Power control also affects the conflict for the medium and the number of hops in turn it will affect the delay time. Transmission power also influences the important metric of energy consumptions. Therefore the energy efficient protocol is must to increase the lifetime of node as well as the lifetime of network [4]. So the designed Ad Hoc routing protocol must meet all these challenges to give the average performance in every case.

Routing is the process of path establishment and packet forwarding from source node to sink node. It carried out in two steps, first selecting the route for different pair of source-sink and delivers the data packets to the target node. Various protocols and data structures are available to maintain the routes and to execute this process. This survey paper is paying attention on how these protocols are selecting energy efficient routes. Routing in ad-hoc networks has some distinct characteristics such as, Energy of node which depends on the limited power supply battery, Mobility of the nodes which may cause frequent route failures and Wireless channels required variable bandwidth compare to wired network. The key solution for the above requirements is energy efficient routing protocols [5].

In the protocols the energy efficiency can be achieved by using efficient metric for selection of route such as cost, node energy, and battery level. The energy efficiency is not intended only on the less power consumption, it also focuses on increasing the life time of node where network maintains certain performance level [6]. Recently it is reported in the literature that energy efficiency can be made at all layer of the network protocol stack. Various study recommended different

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techniques for handling the energy issue. In this paper we discussed the features of few protocols which increase the network lifetime and performance and propose a technique to minimize the consumption of energy as well as increase the lifetime of network.

The technique recommended pertain power control at node level to condense the transmission power of a node and energy-inefficient nodes are detached to increase network lifetime. The rest of the paper structured as follows. Section II presents related work. Section III addressed on the classification of routing techniques based on different approaches and conventional properties of various routing. Proposed energy efficient technique is discussed in section IV and finally Section V Concludes the paper.

2. Related Work

This section consists of complete study on conventional protocols and energy efficient protocols published in different journals which has proposed so much innovation and new ideas in this field. Since energy preservation is an open issue to all layer of the network protocols stack, and power is main anxiety in mobile ad-hoc wireless networks different techniques were recommended by different study and focus has been given on different layer design to preserve energy more efficiently. None of the energy efficient protocol can perform well in every condition[7, 8]. It has some advantages and inadequacy which depends on the network parameters. Energy preservation on the mobile nodes should maintain not only during active communication but also when they are inactive[9]. The standard protocols proposed for wireless networks have two types of power managements [10]. First type is power save (PS) mode for infrastructure based wireless network and the second type is named as independent basic service set power save (IBSS PS) mode, which is for infrastructure-less networks. In the first method, power consumption of the nodes in PS mode is less than the power consumption of nodes which are in active mode. The power saving mechanism is implemented using the access points in the network. But this is not suitable for ad hoc network environment since there is no central coordinator like access point. Conversely, IBSS PS mode is applicable to entirely connected single hop network where all the nodes are within the radio range of each other. Coordinated beacon interval is reputable by the node which initiates the IBSS and is maintained in a distributed approach.

Dynamic power saving mechanism [DPSM] is a conflict of the above protocols we discussed by using the concept of adhoc traffic indication message (ATIM) window and beacon interval. During ATIM window all nodes are conscious and those nodes have no traffic to receive or send are goes to sleep mode after the end of ATIM window. In the paper author Freeny [11] concluded that if ATIM window is fixed then energy saving cannot be efficient. DPSM improves this performance by using the variable ATIM window.

It allows the sender and receiver node to change the ATIM window dynamically. The ATIM window size can be increased while a few packets are still in waiting stage after the current window has expired. The data packets carry the current length of the ATIM window to help the nodes to adjust their ATIM window length. The energy saving performance of DPSM is better as compare to IEEE 802.11 distributed coordination function (DCF) in term of power saving but it is more complex in computations. The author Sahoo [12] proposed a distributed transmission power control protocol for wireless network to achieve energy conservation at the level of node. The protocol uses distributed algorithm to construct the power saving hierarchy topologies without taking the local information of the nodes and provide a simple way to keep the network on account of changing the transmission power.

3. Classification of Routing Techniques

Transmission power control, load distribution and Power Management are the approaches to minimize the energy on active communication and sleep/power-down approach is used to minimize energy during inactivity. The protocols are designed based on the energy related metrics like energy consumed per packet to provide the minimum power path which is used to minimize the overall energy consumption for delivering packet. The next important metric is inconsistency in node power levels which is a simple indication of energy balance and in turn it can be used to extend network lifetime.

Table 1: Techniques of power aware routing protocols.

Here the transmission power is to be fine-tuning to transmit packets using intermediate nodes [13]. It is like a finding shortest path in a graph problem, where each edge is weighted with the distance corresponding to the required transmission power as shown in the fig.1 (e.g., p(SA) for the edge S->A). Finding the most energy efficient route from *S* to *D* is equivalent to finding the shortest path in the weighted graph.

The following Fig.1 illustrates the technique of transmission power control using two models. In the constant link model the routing path S-> D is direct path without fine tuning the transmission power. But in the adjustable model *S- >B- >D* is more energy efficient than the route *S->D* since $p(SD) > p(SB) + p(BD)$. Node *S* preserve energy by lowering its radio power just enough to reach node *B*, but not enough to reach node *D*.

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conditions	Name of process	purpose
Minimize Active Communication Energy	Transmission power control	The total transmission energy is minimized by avoiding low energy nodes.
	Load distribution	Distribute load to energy comfortable nodes.
	Power management	Minimize the energy consumption by using separate channels for data and control.
Minimize Inactivity Energy	Sleep/power-Down mode	Minimize the energy consumption when node in an idle state.

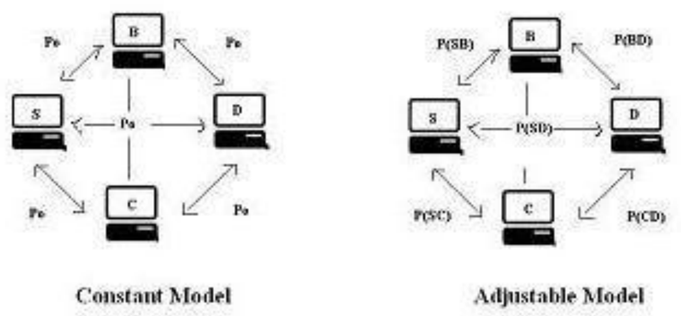

Fig.1 Transmission level power control.

The routing protocols available under the technique transmission power optimization[16] is uphold additional information at each node other than that acquired during operation such as link costs of all edges , costs of all nodes and data generation rate at all nodes . With the help of the information available the protocol select the max -min path among a number of best min-power paths and few protocols regulate the transmission power just enough to reach the next hop node in the given routing path.

The objective of the load distribution approach is to balance the energy usage of all nodes by selecting a route with nodes which are not used frequently instead of the shortest route [15]. The result of this approach may involve more nodes in a route but packets are routed only through energy comfortable intermediary nodes. Protocols based on this approach are not necessarily offer the lowest energy route, but prevent certain nodes from being overloaded, and guarantees for longer network lifetime. One of such protocol is named as Localized Energy-Aware Routing (LEAR). The LEAR routing protocol is conflict from DSR in the process of route discovery procedure for balanced energy consumption. In DSR, when a node receives a route-request message, it attaches its identity in the header of message and forwards it in the direction of destination [17]. Therefore, an intermediate node always relay messages if the corresponding route is selected. On the other hand, in LEAR, a node has to decide whether to forward the route -request message or not depends on its residual energy. If the residual energy is higher than a threshold value, then the node forwards the route-request message. Otherwise, it abandons the message and decline to participate in transmitting packets. Consequently, the destination node will receive a route-request message only when all intermediate nodes in the route have good energy levels, and nodes with low energy levels can preserve their battery power.

The Power Management Based Protocols are focused to achieve the energy efficiency goal by using two separate channels, one channel for control and another for data. RTS/CTS signals are transmitted through the control channel while data are transmitted over data channel. The protocol named power aware multi-access protocol (PAMAS)[18,20] in which the nodes sends a RTS message over the control channel when it ready to transmit and waits for CTS, if the CTS message not receives within a precise time then node enters to a power off state. In the receiving end, the node transmits a busy tone over the control channel to its neighbors when its data channel is busy. The control channel is used to determine when and how long the node to be in power off state. After turn to active state, a node can transmit data over the data channel. Conversely,

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once CTS is received, then the node transmits the data packet over the data channel.

Contrasting the previous techniques discussed, the sleep/power-down mode approach focused on inactive time of communication [17]. In MANET when all the nodes in a sleep mode packets cannot be delivered to a destination node. To overcome this problem, choose a special node named as *master* which can manage the communication on behalf of its neighboring slave nodes. At this moment, slave nodes may be in sleep mode for saving battery energy. Each slave node once in a while wakes up and communicates with the master node to detect if any data it has to receive or not. If no packed for the slave it may back to previous mode to save energy. In a multihop MANET, more than one master node can identified to handle the entire MANET. Fig.2 shows the master -slave network architecture, where nodes except master nodes can save energy by setting their power hardware into low state.

Geographic Adaptive Fidelity (GAF)[19] is the protocol fall under this category which uses location information to determine node equivalence with the help of GPS. The algorithm divides the entire network area into small virtual framework. The nodes present in one virtual framework can communicate to the nodes present in its neighboring framework. Here the power management technique applies to place some of the node in to sleep state to conserve energy. The nodes can be in any of the states like, discovery, active or sleep.

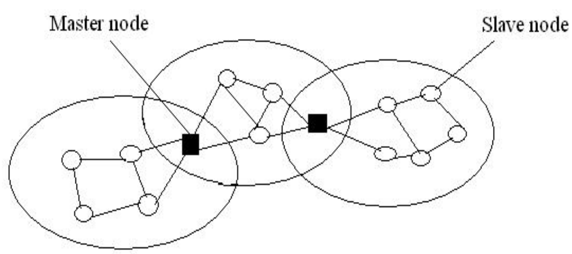

Fig.2 Master-slave Architecture

It applies load balancing approach to balance the lingering energy in a distributed manner. Any node with maximum lingering energy became the active node while its neighboring node goes to sleep state. This approach initiates more computation delay, extra messaging overhead, more energy consumption at each node.

4. Proposed Power Aware Technique

In this section we present the outline of our proposed technique. We regard as a network which consists of *N* nodes organized at randomly in the given area. We assume that all nodes may transmit at any power level P which is ≤ Pmax. All nodes that wish for transmission in the current session should have the minimum residual energy that is 15% of maximal battery capacity. We also assume that all nodes maintain their residual capacity all the time and have maximum bandwidth resources. When the node has capacity which is less than 15% of initial capacity, we push the node become in the sleep mode and marked it as rationally dead. It cannot forward packets to any further extent, but still it has enough energy to send packets. The node which marked as rationally dead can forward the high priority packet when this node is the only node that can forward the packet to destination node. After propel few packets in this emergency stage the node to become referred as actually dead. The algorithms proposed so far are minimize energy consumption per packet, consequently it minimize the total power needed to transmit a packet in a established route, or the algorithms focus on load distribution where the objective is to extend the minimum lifetime for the node. On the other hand, minimizing energy consumption is not taking care of the residual capacity of nodes, which decreases the life time of node when the traffic through the node is higher.

Thus using power aware algorithm may exhaust all their energy very fast and die within a short period of time. On the other hand, when load distribution algorithms are used with the main consideration of power by each node, not taking into account the cost inspired during transmissions. It may lead to involve more number of nodes in the route. The proposed solution consists of using the algorithm which combines both energy consumption and shortest path for route algorithms and it also consider the node's residual capacity. As a result, we suggested that always using the path that consists of nodes having enough residual capacity which is larger than some predefined threshold. The objective of applying both techniques is to minimize the total power consumption by avoiding nodes with minimum battery lifetimes as well as increase the lifetime of network.

5. Conclusion

A Mobile Ad Hoc network (MANET) is a collection of nodes that can communicate with one another without any fixed networking infrastructure. Energy efficiency is one of the main problem in a MANET, especially in designing a routing protocol. In this paper, We surveyed and classified a number of power aware routing techniques. Each technique has its own assumptions and different objectives and different methodologies in the implementation. For instance, in the transmission power control approach the power level is essential but the cost is not considered. The load distribution approach is efficient to improve the energy imbalance problem. There are different channels for sending data and control packets to reduce the energy consumption in power management approach but it increase the network traffic. The sleep/power-down mode approach is different from the other approaches as it focuses on inactivity energy. The proposed power aware algorithm combines the features of existing techniques to decrease the power consumption and increase the lifetime of node & network.

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