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# A Survey on Power Aware Routing in Manet

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***Abstract— Adhoc network is a network without centralized administration in which different users can communicate and ex-change information. Mobile Ad-hoc Network (MANET) is a self configuring self organizing collection of mobile ad-hoc nodes with no fixed infrastructure. The node is free to move and the network topology changes rapidly. As the nodes in Mobile Ad hoc Network (MANET) have limited battery so power is always an issue in MANET. Power failure of node in MANET not only affects the node itself but also affects its ability to forward the data packet to the next hop and thus reduce the lifetime of network. In order to maximize the lifetime of the network energy consumption of each node must be controlled. This paper survey different energy related metrics used in Routing and some power aware routing protocols***

***Keywords— Mobile Adhoc Network, Energy related metrics, MTPR, MBCR, MMBCR and CMMBCR.***

## I. INTRODUCTION

The wireless network can be classified as Infrastructure wireless network and Infrastructure less wireless networks. In Infrastructure wireless network the base station is fixed and mobile nodes can move from their position during communication. As the nodes move it go out of range of one base station and come in range of other base station. In Infrastructure less wireless network there is no base station and nodes are mobile and move during communication..It is also called as Ad-hoc Network [1]. Mobile Ad-hoc Network (MANET) is a self configuring self organizing collection of mobile ad-hoc nodes with no fixed infrastructure. The node is free to move and the network topology changes rapidly. As the node move during communication, links are formed and broken. The infrastructure changes due to mobility of nodes. Mobile ad hoc network (MANET) is an infrastructure-less multi hop network where each node communicates with other nodes directly or indirectly through intermediate nodes. Thus, all nodes in a MANET basically function as mobile routers participating in some routing protocol required for deciding and maintaining the routes. Since MANETs are infrastructure-less, self-organizing, rapidly deployable wireless networks, they are highly suitable for applications involving special outdoor events, communications in regions with no wireless infrastructure, emergencies and natural disasters, and military operations. As a router it is used to forward the packet to other host. .There may be unidirectional links between nodes. Due to the limited transmission range of wireless network nodes, multiple hops are usually needed for a node to exchange information with any other node in the network [1],[ 2],[ 3]. In MANET nodes act as both host and routers. If the source and destination are in direct transmission range of each other then they directly exchange packet between them, but if the source and destination are not in direct transmission range of each other then intermediate node is used to forward the data packet and this is called routing. It mainly involves two activities: finding optimal path and transfer information. Routing is one of the key issues in MANETs due to their highly dynamic and distributed nature. In particular, energy efficient routing may be the most important design criteria for MANETs since mobile nodes have limited battery capacity. In ad hoc networks mobile devices are battery operated and the battery technology has not been improving rapidly. Therefore power consumption is likely to remain an issue in mobile wireless network routing. Since communication of two nodes relay on other intermediate nodes. The death of a small set of nodes with depleted power might cause partitioning of the network. The lifetime of the entire ad hoc network can be increased by improving the power consumption balance among nodes and the connection of the network. Power failure of a mobile node not only affect the node itself but also its ability to forward packets on behalf of others and thus the overall network lifetime is also affected. For this reason, many research efforts have been devoted to developing energy aware routing protocols.

## II. Routing Protocols For Mobile Ad-Hoc Network

The routing protocols proposed for MANETs are generally categorized as table-driven and on-demand driven based on the timing of when the routes are updated. With table-driven routing protocols, each node maintains routing information to every other node in a network. The routing information is stored in routing table which is update periodically to maintain latest information of network as the network topology change dynamically due to mobility of nodes. The routing table maintained before communication start. These protocols are not good for large network because they maintain route information to all nodes even if the routes are not needed. The protocol may waste the bandwidth because control message are sent to maintain correct route information when there is no data traffic [1],[ 3]. Many routing protocols including Destination-Sequenced Distance Vector (DSDV) and Fisheye State Routing (FSR) protocol belong to this category, and they differ in the number of routing tables manipulated and the methods used to exchange and maintain routing tables. With on-demand driven routing, routes are discovered only when a source node desires them. Route discovery and route maintenance are two main procedures: The route discovery process involves sending route-request packets from a source to its neighbour nodes, which then forward the request to their neighbours, and so on. Once the route-request reaches the destination node, it responds by unicasting a route-reply packet back to the source node via the neighbour from which ***it*** first received the route-request. When the route-request reaches an intermediate node that has a sufficiently up-to date route, it stops forwarding and sends a route-reply message back to the source. Once the route is established, some form of route maintenance process maintains it in each node's internal data structure called a route-cache until the destination becomes inaccessible along the route [1],[ 3]. Dynamic Source Routing (DSR) and Ad-Hoc On-Demand Distance Vector (AODV) are examples of on-demand driven protocols.

### *2.1 DSR (Dynamic State Routing)*

Dynamic Source Routing protocol [4] gets its name from the concept of source route, where the source node S includes list of all intermediate nodes (through which the packet would traverse) in the packet itself, whenever it desires to send the packet to a destination node D in an ad hoc network. In case there is no route available in the cache, S initiates a Route Discovery procedure. Each route discovery may discover multiple routes and all routes are cached at the source node. The protocol is based on two basic processes: (a) the route discovery process and (b) the route maintenance process. In the route discovery procedure a node wishing to establish a route broadcasts a route request (RREQ). Each node receiving the RREQ appends its own address to the packet header and rebroadcasts it. The RREQ flooding terminates when it reaches either the destination or an intermediate node with a route to the destination. In this case a route reply (RREP) containing the series of accumulated addresses is sent back to the source .Upon receiving the RREP, the source node can start transmitting the data packets towards the destination using the route recorded in the RREP. Each node running the DSR protocol is equipped with a route cache which maintains the routes that a node is aware about. DSR uses the cache intensively in order to reduce the overhead caused by the route discovery. The major objective of the route maintenance procedure is to detect a broken link and find a new route to the destination. When a node along an established route detects a link disconnection due to the neighbour's movement, it informs the source using the route error (RERR) packet. The source then removes the broken link from its cache and attempts to find a new route to the intended destination.

## III. Related Work

Power is one of the most important design criteria for Adhoc networks as batteries provide limited working capacity to the mobile nodes. In order to facilitate communication within a Mobile Adhoc Network, an efficient routing protocol is required to discover routes between mobile nodes Power failure of a mobile node not only affects the node itself but also its ability to forward packets on behalf of others and hence affects the overall network lifetime. Much research efforts have been devoted to develop energy aware routing protocols. Different approaches can be applied to achieve the target Transmission power control and load distribution are two approaches which minimizes the active communication energy, and sleep/power-down mode is used to minimize energy during inactivity. The primary objective is to minimize energy consumption of individual node. The load distribution method tries to balance the energy requirement among the nodes and increases the network lifetime. This can be done by avoiding over-utilized nodes while selecting a routing path. Transmission power control approach, the stronger transmission power is used to increase the transmission range and reduces the hop count to the destination, if weaker transmission power is selected then it makes the topology sparse, which partitions the network and produces high end-to-end delay due to a larger hop count. In [9] the author develops a protocol named as EPDSR which is extension of DSR. In this author develop a new route discovery algorithm to efficiently utilize the power using a new cost function. The new protocol prevents the overuse of small set of nodes and ultimately extends the network partition time. In [10] the authors propose an efficient algorithm named as PAR, which maximizes the network lifetime by minimizing the power consumption during the source to destination route establishment. As a case study proposed algorithm has been incorporated along with the route discovery procedure of AODV. In [11] the authors also need to maximized the lifetime of network and develop an energy efficient algorithm named as SPAR. The algorithm is implemented using AODV protocol in NS 2 and compares the result with AODV and PAR.

## IV. Energy Efficient Routing Approaches

In contrast to simply establishing correct and efficient routes between pair of nodes, one important goal of a routing protocol is to keep the network functioning as long as possible. this goal can be accomplished by minimizing mobile nodes' energy not only during active communication but also when they are inactive. Transmission power control and load distribution are two approaches to minimize the active communication energy, and sleep/power-down mode is used to minimize energy during inactivity [8].

### *4.1 Transmission power control approach*

This approach is based on active communication energy of node. The active communication energy can be reduced by adjusting the radio power of each node to reach the receiving node. This transmission power control approach can minimizes the total transmission energy required to deliver data packets to the destination. If node's radio transmission power is under control, their direct communication ranges as well as the number of its immediate neighbours are also adjustable. While stronger transmission power of node increases the transmission range and reduces the hop count to the destination, weaker transmission power makes the topology sparse which may result in network partitioning and high end-to-end delay due to a larger hop count.

### *4.2 Load distribution approach*
This approach is also based on active communication energy. The main goal of this approach is to balance the amount of energy usage among the nodes and to maximize the lifetime of network by avoiding over-utilized nodes when selecting a routing path. Protocols based on this approach do not only provide route with lowest energy, but prevent certain nodes from being overloaded, and thus increases the network lifetime.

### *4.3 Sleep/Down Power mode*
This approach is based on saving the energy during inactivity means when node is idle. Nodes can save the energy during inactivity by switching into sleep/power-down mode when there is no data to transmit or receive. This leads to considerable energy savings, especially when the network environment is characterized with low duty cycle of communication activities. However, it requires well-designed routing protocol to guarantee data delivery even if most of the nodes sleep and do not forward packets for other nodes.

## V. Energy Related Metrics In Manet
Many researchers focused on designing protocols to increase the network lifetime, lifetime of node , reducing the energy consumption by evenly distribute the power consumption rate of each node. We need to use appropriate metrics to help us design power-aware protocols which can select optimized paths that are power-saving for nodes with lower battery capacities and higher traffic loads. Here we give brief introductions to several power-aware metrics that do result in energy-efficient routes as presented in [5].

### *5.1 Minimize Energy consumed/packet*
This is one of the most important metrics. The total amount of energy for sending data packet along a route is the sum of energy consumed by each node. The total energy consumed can be minimized by minimizing the energy consumed per packet.. So to conserve energy, we want to minimize the amount of energy consumed by all packets traversing from the source node to the destination node. That is, we want to know the total amount of energy the packets consumed when it travels from each and every node on the route to the next node. The energy consumed for one packet is thus given by the equation:

$$E = \sum_{i=1}^{k-1} T(n_i, n_{i+1})$$

Where ni to nk are nodes in the route while T denotes the energy consumed in transmitting and receiving a packet over one hop. Then we find the minimum E for all packets.

### *5.2 Maximize Network lifetime*
In network topology, we can find a minimal set of nodes whose removal will cause the network to partition. Network lifetime is the time until removal of these small set of nodes will cause network to partition. The connection of the nodes in the two partitions must go through some of critical nodes. To prevent the network partition we must prevent overuse of these small set of critical nodes. A routing procedure must therefore divide the work among nodes to maximize the lifetime of the network.

### *5.3 Minimizing Power variance among mobile nodes*
The main aim of this metric is that the routing algorithm must assign fair energy distribution among all nodes.. This metric ensures that all the nodes in the network remain up and running together for as long as possible. It achieves the objective by using a routing procedure where each node sends packets through a neighbour with the least amount of packets waiting to be transmitted. In this way, the traffic load of the network is shared among the nodes with each node relaying about equal number of packets. Therefore, each node spends about the same amount of power in transmission.

### *5.4 Minimize Cost/Packet*
This metric is mainly based on the level of battery capacity remaining in a node. Those nodes with a low value of this metric are not chosen (unnecessarily) for a route. This metric is defined as the total cost of sending one packet over the nodes, which in turn can be used to calculate the remaining power. It is given by the equation:

$$C = \sum_{i=1}^{k-1} f_i(x_i)$$

Where xi represents the total energy expended by node i so far and f is the function that denotes the node cost.

### *5.5 Minimizing maximum node cost*
This metric try to minimize the cost consumed by mobile node when forwarding a data packet through it. Minimizing the cost per node result in significant reduction in maximum node cost.

 

## VI. Power Aware Routing Based On Metric Of Energy Consumption

### *6.1 Minimum Total transmission power Routing (MTPR) [6]*

MTPR focus on minimizing the total transmission power consumed without considering remaining energy of node. As the packet is transmitted through selected route MTPR minimize the total energy consumption. MTPR does not maximize the network lifetime because it does not consider the remaining energy of the node. Suppose we consider a route as

rd = n0,n1,.....nd

Here n0 is the source node and nd is the destination node. An energy function P(ni,ni+1) represent transmission energy over the hop ni and ni+1 and the total transmission power for the route l is calculated as:

$P_l = \sum P(ni,ni+1)$, for all the nodes in the route, where $0 \le i \le d-1$.

So the desired route k will be:

$P_k = \min P_l$ , where l ε A and A is the set containing all the routes.

Since transmission power depends on distance, such as transmission power is proportional to $d^{\alpha}$, where d is the distance between two nodes. MTPR prefer routes with more hops having short transmission range then those with fewer hop but long transmission range.

### *6.2 Minimum Battery Cost Routing (MBCR) [6]*

The disadvantage of MTPR is that it only considers total transmission power. It does not increase the network lifetime. If the specific host is always on the minimum total transmission power route, the battery power of this host will be deplete quickly. To overcome this node's residual power can be used as a cost metric in route selection. MBCR [17] minimizes the path battery cost so as to maximize the total remaining battery capacity. The cost function f in MBCR is defined such that the lower the remaining battery capacity c of a node i, the more reluctant the node is to receive and forward a packet. One possible f is :

$$f_i(c_i) = \frac{1}{c_i} .$$

It reflects that as a node's battery capacity decreases, the cost to include the node into the routing path proportionally increases. A full routing path is determined by summing the costs along the path, and selecting the path incurring minimum total battery cost.

$$R_j = \sum_{i=0}^{D_j - 1} f_i(c_i)$$

$$R_i = \min\{R_j \mid j \in A\}$$

By using residual power as a cost metric, MBCR prevents nodes from being overused, and attempts to evenly distribute battery capacity over the network to increase network lifetime. It is capable of selecting a route with fewer hops when all nodes have similar battery capacities. As MBCR consider only total battery cost function it may happen that the route containing nodes with less remaining battery may still selected and thus decrease the network partition time.

### *6.3 Min-Max Battery Cost routing*

In MBCR only total battery cost function is considered so the route containing nodes with less remaining battery is still selected. To avoid using specific nodes S.Singh et al. Proposed MMBCR [6] in which cost function is modified to avoid selecting routes containing nodes with less battery capacity. MMBCR [6],[ 7] allow nodes with high battery capacity to participate in routing more often the nodes with less residual power. The battery will be used more fairly. MMBCR define route cost as:

$R_j = \max f_i (c_i)$, Where node i is the set of all the nodes along route j.

The desire route k satisfies:

$R_k = \min R_j$ , Where j is set of all possible routes.

MMBCR maintain nodes' battery capacity at approximately a fair level by avoiding the allocation of workload to nodes with less power. MMBCR does not guarantee that under all circumstances minimum total transmission power route is selected. Since MMBCR consider weakest node over the path, a route with best condition among the paths impacted by each weak node along path is selected.

### *6.4 Conditional Min-Max Battery Cost Routing*

Minimizing each node's battery consumption and maximizing network lifetime are two goals in designing power-aware routing schemes. CMMBCR combines both in route selection criteria. CMMBCR [6],[ 7] uses battery capacity instead of cost function as a route selection metric. It defines the battery capacity for route Rj at time t as:

$R_j = \min c_i(t)$, where node i is the set of all the nodes along route j.

For route selection we consider two sets A and B, where A is set of all the routes and B is the set of all possible routes

with $R_j \ge \gamma$ ,where γ is fixed threshold. For route selection if all the nodes in path have remaining battery capacity greater than γ choose the path by applying MTPR, else select the route R with maximum battery capacity by applying

 

MMBCR. The performance of CMMBCR depends greatly on the chosen value of γ. The CMMBCR consider both the total transmission power and the remaining battery capacity of node

| Dominating Metrics | Power-aware routing protocols |
|---|---|
| Total energy per packet | MTPR |
| Total Battery consumption per packet | MBCR |
| Critical nodes remaining battery capacity | MMBCR<br>CMMBCR |

**Table 1: Showing Power-aware protocols with respect to dominating metrics.**

## VII. CONCLUSIONS

A mobile ad hoc network (MANET) consists of autonomous, self-organizing and self-operating nodes, each of which communicates directly with the nodes within its wireless range or indirectly with other nodes via a dynamically computed, multi-hop route. In order to facilitate communication within a MANET, an efficient routing protocol is required to discover routes between mobile nodes. Energy efficiency is one of the main problems in a MANET, especially in designing a routing protocol. In this paper, we surveyed and classified a number of energy aware routing schemes. To conserve the active communication energy Transmission power control and load balancing approaches are used. The sleep/power-down mode approach focuses on inactivity energy. So the main concern for conserving power of nodes in MANET and increasing the lifetime of network is to consider the remaining energy of node before sending the data through it.

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