Role of Parameters in Different Energy Efficient Routing Protocols in MANETs

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ABSTRACT
A mobile adhoc network is a dynamically reconfigured wireless network with no fixed infrastructure. Highly dynamic and distributed nature of the MANETs makes routing a major issue. The high mobility of the nodes results in rapid changes in the routes, thus routing in MANETs consumes huge amount of power and bandwidth and undergoes frequent topology changes to which it adjusts quickly. Energy becomes an important issue in mobile adhoc networks since mobile nodes will be powered by batteries with certain specified capacity. Hence there have been various energy efficient routing protocols which minimize the active communication energy or inactive energy. There are various parameters used by energy efficient protocols to find the best energy rich routes. The purpose of this paper is to summarize different parameters used by protocols to keep the network functioning as long as possible. These parameters are used to compare the energy utilized in various available routes, thus choosing the best route with minimum energy consumption to increase overall network lifetime as much as possible with less battery consumption at each node.

Keywords
MANET, DSR, AODV, ZRP, FSR, DSDV, CBEERP EESRP.

1. INTRODUCTION
Mobile adhoc network (MANET) [1] allows each node to communicate with other nodes directly or indirectly via intermediate nodes, thus forming an infrastructure-less multi hop networks. Thus, all nodes in a MANET are mobile routers that participate in some routing protocol that decides and maintains the routes [1]. MANET consists of many mobile nodes, communicating with each other in the network. These mobile nodes are powered by a limited amount of battery life. The degraded performance of the MANETS as well as the major fact that mobile nodes run out of energy quickly, has been an issue due to the resource constrained nature of MANET that leads the network to suffer from many challenges in its design and operation. Many protocols have been specially designed for MANET which are energy efficient, power management and power dissemination. These protocols take energy as the major issue as energy consumption is an essential design issue in preserving the longevity of the network. Thus Energy efficiency is the major concern in the mobile ad-hoc network [23]. Since mobile nodes are powered by batteries with limited capacity. The reason behind the issue taken in concern is that power failure of a mobile node not only affects the node itself but also its ability to forward packets on behalf of others and thus the overall network lifetime. Hence various energy efficient algorithms are emerging. An energy efficient routing is a critical problem in wireless networks due to the severe power constraint of wireless nodes. The nodes in the network are provided by the batteries. The batteries are with limited lifetime energy. This energy is inspired during transmission, reception and overhearing and many other reasons. It is very difficult to replace batteries or to re-charge them. If power goes down, the network connection will not be present, and will influence our transmission also. Hence defining strategies to reduce the wastage of energy consumption at different levels is a major issue [20]. Therefore the main task of a routing protocol is to keep the network into function as long as possible by saving the energy consumption both during active and inactive mode[4].

The major objective of the energy efficient routing protocols should not only be establishing the correct and efficient routes between the a source and destination, but also to keep the networks functioning as much as possible with less battery consumption at each node[8]. Many routing protocols that are proposed to make packet forwarding between nodes energy efficient, by using various energy metrics like average energy consumption, network lifetime, energy drain rate, etc. [5]. Efficient routing protocols are needed for Ad Hoc networks, especially when there are no routers, no base stations and no fixed infrastructure. All energy efficient routing protocols uses various parameters to decide and set the amount of energy utilized. Then further this energy is minimized by various selection processes.

2. VARIOUS ENERGY EFFICIENT ROUTING PROTOCOLS AND THEIR PARAMETERS
The following are various energy efficient routing protocols which are proposed by enhancing the basic routing protocols in mobile adhoc network. The description of the protocol is done along with specifying the parameters involved. The algorithm uses different parameters to make the consumption of the energy minimized and thus increasing the lifetime of the network.

2.1.Energy Effecient DSDV Protocol
DSDV protocol had two problems that led to the wastage of energy. First was the large number of route replies because the reply is sent through all available routes. Second was the forwarding of the packets involved the utilization of the equal energy irrespective of the distance between the adjacent nodes.

EEDSDV [6] protocol uses unicasting of the packet instead of multicasting or broadcasting by using the transmission energy of the nodes to send the route reply and to transmit the data. This transmission energy of the nodes is tuned according to the relative distance between the nodes involved in the network [6]. The use of a multihop network is done in sending the route request packet to the destination. The route request packet is sent along with the size of the network and number of nodes in the network. The procedure to send the route reply packet is a little different. It involves the most active route out of the routes involved in sending the request to participate, thus the route from which the destination has received the first Route Request

is chosen. The network node takes the route with the most recent sequence number to provide the available route. Hence the sequence number is a major parameter. The other parameter involved is the trip time. This trip time is further used to calculate the distance between the nodes. The calculation of trip time between two nodes in the selected path is done by means of the time taken by the Route Reply message. The calculation of the Trip Time (TT) is done by sending a route reply message from the local node to the remote node. When a route reply message is sent from the destination to the source, the destination node sends its current time in the header of the route reply message. The previous node calculates the trip time by subtracting the time in the header of the message from its current time which is naturally higher. By this method all the nodes calculate the trip time of the message. Then the distance is calculated by the formula-

*Distance (d) = TT * c where c* ≈ 3 ×108 *m/s.*

C is the speed of light, while the distance (d) is the length of the neighboring nodes in the selected path from source to destination. The other parameters involved is the Variant Transmitted Energy (VTE).

2.2.Energy Efficient DSR Protocol

Based on the two approaches which are transmission control and load balancing DSR[15] protocol can be modified and enhanced to form an energy efficient routing protocol. One of the modified protocols uses the first phase to decide the route based on the load balancing approach and in the second phase it dynamically adjusts the transmitting power at every node before it transmits the packet. It uses parameters like minimum hop count while selecting the path and having fixed transmitting power, the current energy level and the current transmitting power level of individual nodes, as it assumes that the ratio of the current power level and the current transmitting power is nothing but the depletion rate of the battery [8].

Another proposed protocol, which uses DSR as the base protocol is ENERGY EFFICIENT POSITION BASED ROUTING PROTOCOL [10] in which all the routes are defined along with the number of intermediate nodes from source to destination called hop count. Then the minimum value of all parameters like hop count, bandwidth, residual energy and load are calculated. Then position count is calculated in the final position table on the basis of next mentioned four rules. A specific route is selected having a minimum value of position count. That specific route will be best suitable for all aspects like having maximum available residual energy and bandwidth etc. [10].

The best route is selected on the basis of following rule set on the basis of minimum value of all parameters [9, 10]:

1) **Step 1:** If two or more than two routes have equivalent energy: Then Route with maximum available bandwidth will be accepted.
2) **Step 2:** If two or more than two routes are of the same energy and equivalent bandwidth: Then the Route having minimum Load will be considered.
3) **Step 3:** If two or more than two routes have equivalent energy, equivalent bandwidth and equal load even then Route with minimum hop count value is considered
4) **Step 4:** If all the available routes are not of equal energy: Then Route with maximum residual energy, maximum bandwidth, minimum load and minimum hop count should be given priority [9,10].

Hence the parameters like hop count, bandwidth, residual energy, load, energy forms the basis of the protocol.

2.3.Energy efficient AODV routing

AODV routing in mobile adhoc network does not consider energy as a metric. Energy consumption being an important issue, shortest path is not always an optimal path in terms of energy. Due to the cost optimality the nodes involved in the shortest path are used frequently and thus their energy along these routes will be consumed quickly and they may exhaust their batteries faster. This may lead to the switching off devices faster and going out of network and thus disconnected sub-networks[11].

Energy Efficient Ad Hoc On-demand Distance Vector protocol (EE-AODV) has enhanced the RREQ and RREP handling process to save the energy in mobile devices. EE-AODV considers some minimum energy level which should be there in all the intermediate nodes participating in the route. If the node has its energy less than the minimum energy level, it should not be participating in the route until and unless no other route is available. The protocol works as follows-

- The source initiates the path discovery process to the destination if no route information is present in its routing table.
- Every node maintains the route availability and energy consumption for that route.
- Whenever a source node sends a RREQ to its neighbors for route discovery of the destination node, the neighbor node should send its energy level REPEL (Reply Energy Level) in response to that RREQ, if path to destination node is available. If the path to Destination node is not available the neighbor node should send RERR [11].
- The source node discards the node whose REPEL value is a threshold or less than that till the time it has another option to send the data.
- After discovering the route from source to destination node, source node should consider the neighbors which are having a path to destination node as well as the maximum energy level as its next hop[11,12].

Energy Calculation

TP - transmit Power for one packet,

TT - transmit Time of one packet,

So,

ET - amount of energy ET consumed during transmission of 1 packet

ET=TP x TT - (1)

Hence, Remaining Energy Enew of node will be,

Enew = Ecurr - ET -(2)

RP - the receiving Power for one packet,

of one packet,

So,

ER - the amount of energy ER consumed during receiving of one packet.

ER=RP x RT - (3)

Hence, Remaining Energy Enew of node will be,

Enew = Ecurr - ER -(4)

Energy of node at any interval of time is calculated by this method [13].

So the parameters used by this protocol are transmit power, transmit time, receiving power, receiving time.

2.4.Energy efficient shortest path routing protocol

Shortest path routing protocol [23] has been one of the easiest algorithm used for finding the best possible route which is shorter in terms of number of hops. A slight modification in the existing algorithm is done to find the energy efficient routes [14]. In EESP [14] route computation is based not only on the distance but also on the residual energy in the nodes.

The algorithm works as follows-

- On initializing the network a threshold value is set. This threshold value should be on the range such that no unnecessary route initiation should take place and any node should not be denied to initiate its own communication due to the battery extinction.
- The initial node is assigned to 0 and all other nodes to 1. The distance between the nodes is considered as 1 to show the connectivity else it is taken as 0.
- Marking all the nodes as unvisited calculate the tentative distance of all its unvisited neighbors.
- Updation of the distance is done taking the least distance, including the effect of the residual energy level of that node taking the energy metric at the denominator of the distance parameter.
- The distance parameter will be higher for low energy nodes and thus making them less likely to be included in the path.
- A node whose energy level is greater than the threshold and has the least distance value is chosen to be the current node for the next iteration.
- The process is repeated for every node till the destination node taking the distance value of the destination node to be the optimal value [14].

Energy Calculation

The energy required for the transmission of a packet for distance d is given by,

ET (d) = Ect+ ε dn -(1)

Where

Ect -the energy consumed by the circuitry at the transmitte

ε -the energy dissipated in the transmitter amplifier

n -design parameter which can be either 2 or 4.

Also the power consumed in receiving is given

ER (d)= Ecr - (2)

Ecr - the energy consumed by the circuitry at the receiver

Total energy will be the sum of energies in (1) and (2)[14].

The distance, energy consumed, energy dissipated, threshold value helps the protocol in finding the best route .

2.5.Cluster based energy efficient routing algorithm (CBEER)

The remaining energy level of a node is the basic parameter used by this protocol to select the best energy efficient route. The energy aware route establishment and route maintenance is the basic function of CBEER [15] protocol.

Root Establishment

The establishment of the route in an adhoc network by CBEER protocol is performed by sequential two main steps that are the discovery of the route being the first and the maintenance of the route being the second [15].

- Route discovery

The remaining energy level of the node is used to discover route in this protocol. The main issue that CBEER[15] protocol solves is establishing the best energy aware route which further helps in avoiding fully energy drained nodes. These nodes form the gateway for other zones. This in turn reduces the flow of unnecessary packets in the network. These unnecessary packets are basically route error and route discovery packets. As the basis of the protocol is the remaining energy level of a node the route that is discovered is not the shortest. The energy level of the node is utilized in transmitting and receiving of the packet and also to find the path that is needed by the packets to detect the destination. Hence, the energy is utilized optimistically and the cache ratio is increased. The network is formed by 'divide and rule' policy. A node on entry to the network gets itself associated with one of the root if its energy level is lesser than the root node else it will act as a root and the node which was a root becomes a leaf node. The node with the highest energy forms the domain of the virtual backbone. The root accepts the route discovery packet, and checks its cache to find the cache entry of the packet. The root replies back with a root reply and forwards the packet if the entry in the cache is absent. Ultimately the route discovery packet is sent to the different domain if the route is nonexistent [15].

- Route maintenance

This step of the protocol is easier to implement as it involves the exchange of the hello packet, which contains the route cache between the leaf and the root. This exchange makes sure that the existing route can be generated from the cache reference. This tree that if formed on the basis of the energy lets the nodes with less remaining power to take part by allowing them to receive and transmit the packets. The tracing of the route and the identification of the root to which the node belongs is done by exchanging the fields the ROOT_NODE or LEAF_NODE along with the sequence number [15,16].

2.6.Optimize Routing Algorithm Based On FSR

The fisheye state routing protocol [18] is a hierarchal routing protocol proactive in nature. The FSR protocol works on the principle of link state routing. In case of the large networks the protocol wishes to reduce the routing update overhead by using a fisheye technique. The concern of the fisheye is to see the nearby objects to the focal point. Hence, this technique works by maintaining the exact information of the nearby nodes and some about the nodes that are far away. The set of reachable nodes within the given number of hops is used to define the scope of fisheye. The size of the network is used to define the levels and the scope along with their radius. The frequency of exchanges between the nodes within the nearer scope is higher there by making the frequency of exchange in the smaller scope

more than the larger. In spite of the fact that the nodes does not have the accurate information about the far away nodes, the assurance of the packet reaching the destination is certain because the information about the nodes keeps on becoming accurate as we come nearer to the destination node. The device runtime battery capacity and the real propagation power loss information forms the basis of optimized routing algorithm using FSR protocol [17,18].

Hence run time battery and propagation loss is considered as the major parameters in the protocol.

2.7.Energy Efficient Improved Zone Routing Protocol

A ZRP [21] protocol works on the mechanism of zone which is defined for each and every node separately. It is a hybrid protocol which uses the best of both proactive and reactive mechanism. The proactive uses large amount of bandwidth and reactive methods apply flooding to detect the routes. It is also defined for the zones of various neighboring nodes which overlap. In ZRP the scope of the proactive is minimized to a zone which is centered on each node. The maintenance of routing information can be done easily. The IZRP [22] uses the concept of querying which is done more efficiently than flooding. This protocol uses energy factor to determine energy consumption.

Algorithm

- The source node when wants to send the packet to the destination checks for the availability of the path. If the path is not available it uses flooding to begin the process of route discovery. A route request packet is broadcasted to all the neighbor nodes with the destination address.
- All the intermediate nodes on receiving the route request packet calculates the energy factor. If its energy factor is greater than the threshold energy it participates in the route discovery process and forwards the packet to its neighbor nodes. Otherwise, the packet is discarded. The above step goes on till the destination node is found.
- When the destination node is found, it generates the RREP packet with source as new destination and sends it back to the source and path is established with all intermediate nodes having good battery life preventing the packet losses due to node failures[22].

Energy Factor Calculation

Energy factor = remaining energy of the node/ initial energy of the node.

Where,

Remaining energy = initial energy - consumed energy[22].

3. SUMMARISATION OF THE PARAMETERS USED BY THE PROTOCOLS

Table 1. Parameters Used By The Protocols

PROTOCOL TYPE	PROTOCOL NAME	PARAMETERS USED	REFERENCES
PROACTIVE	ENERGY EFFICIENT DSDV PROTOCOL	• Sequence number. • Round trip time. • Distance.	[6],[7]
	OPTIMIZED FISHEYE STATE ROUTING PROTOCOL	• Run time battery capacity. • Real propagation power loss.	[17],[18]
	CLUSTER BASED ENERGY EFFICIENT ROUTING PROTOCOL	• Sequence number • Remaining energy.	[15],[16]
REACTIVE	ENERGY EFFICIENT AODV PROTOCOL	• Threshold energy. • Receiving power. • Receiving time. • Transmit power. • Transmit time.	[11],[12],[13]
	ENERGY EFFICIENT DSR PROTOCOL	• Hop count. • Current energy level. • Current transmitting power. • Bandwidth. • Residual power. • Load. • Position count.	[8],[9]
	ENERGY EFFICIENT SPR PROTOCOL	• Energy consumed. • Energy dissipated. • Distance.	[14],[23]
HYBRID	IMPROVED ZRP PROTOCOL	• Remaining energy. • Consumed energy. • Initial energy. • Energy factor.	[20],[21],[22]

4. CONCLUSION

The already existing routing protocols for mobile adhoc networks are optimized and enhanced to design energy efficient routing protocols for mobile adhoc networks. These energy efficient routing protocols are used to overcome the short comings of the mobile adhoc network like limited capacity battery of the nodes, difficulty in replacing the battery, limited life time of the network, wastage of energy. There are many parameters used by these protocols to form the basis of their algorithm. The parameters are sequence number, trip time, distance between two nodes, hop count, current energy level, current transmitting power level, bandwidth, residual energy, load, receiving power, transmitting power, residual energy of the nodes etc.

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