PESR Protocol for Predicting Route Lifetime in Mobile Ad Hoc Networks

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ABSTRACT
The energy consumption is an important issue in Mobile Ad hoc Network (MANET) because nodes have limited battery energy. The exiting protocol EDNR and DSR does not consider the power consumption issue. Many proposed routing protocols for mobile ad hoc networks concentrate on issues like the packet delivery ratio, routing overhead and shortest path between source and destination. In fact, power constraints represent an equally important issue in mobile ad hoc networks operations. A power effective source routing protocol reduces the energy consumption of the nodes in a mobile ad hoc network by routing packets on their routes that consumes the minimum energy to reach their destination. The goal of this protocol is to reduce power consumption in transmission and balance power consumption of nodes to increase the life time of the whole network.

General Terms
Route lifetime prediction algorithm, EDNR Protocol, PESR Protocol, Route Discovery Algorithm.

Keywords
Link lifetime, node lifetime, route discovery, routing protocols.

1. INTRODUCTION
A mobile ad hoc network (MANET) consists of many mobile nodes that can communicate with each other directly or through intermediate nodes. Often, hosts in a MANET operate with batteries and can roam freely, and thus, a host may exhaust its power or move away, giving no notice to its neighboring nodes, causing changes in network topology. Most of the routing protocols do not consider the energy consumption during routing process. This can have an adverse impact on the end to end performance metrics like packet delivery fraction, network life time and link breaks.

Wireless networks can be classified in two types:
1. Infrastructure networks
2. Infrastructure less networks,

Commonly known as ad hoc networks, infrastructure network consist of network with fixed and wired gateways. The mobile unit can move geographically while it's communicating. When it goes out of range of one base station, it connects with new base station and starts communicating through it. While in ad hoc networks all nodes of these networks behave as routers and take part in discovery and maintenance of routes to other nodes in the network. Thus each mobile node operates not only as a host but also as a router, forwarding packets for other mobile nodes in the network that may not be within the transmission range of the source.

Characteristics of Mobile Ad hoc Networks:

- Dynamic topologies:

Since nodes are free to move so the network topology may change randomly and rapidly at unpredictable times.

- Bandwidth constrained variable capacity links:

Wireless links have significantly lower capacity than their hardwired counterparts. Also the wireless links have low throughput.

- Energy constrained operation and Limited Physical Security:

All the nodes in a MANET rely on batteries. So the most important system design criterion for optimization is energy conservation also there are increased possibilities of eaves-dropping, spoofing and denial-of-service attacks.

Applications: Few applications are as:

- PDA's, Laptops, and other portables:

If portable devices were equipped with Ad hoc structure and the density of these devices is good enough, this would allow users to have some sort of network connection at all instances.

- Sensor Arrays:

As planting sensors in the environment becomes more and more common; the range of the environment that can have the sensors is tremendously increased because they do not have to be centered on some sort of central station.

- Military and Emergency applications:

Ad hoc networking will help to create and maintain an information network between the soldiers, vehicles, and military information head quarters

2. AD HOC ROUTING PROTOCOL
The goal of mobile ad hoc networking is to extend mobility. In this paper, two ad hoc routing protocols called as DSR and AODV will be compared that helps to see which kind of protocol is better suited for the ad hoc environment under different conditions.

Why is Routing in MANET Different?

- Link failure/repair due to mobility may have different characteristics than those nodes due to other causes. Also the rate of link failure/repair may be high when nodes move fast.
- New performance criteria may be used as, route stability despite mobility and less energy consumption. Also no single protocol works well in all environments.

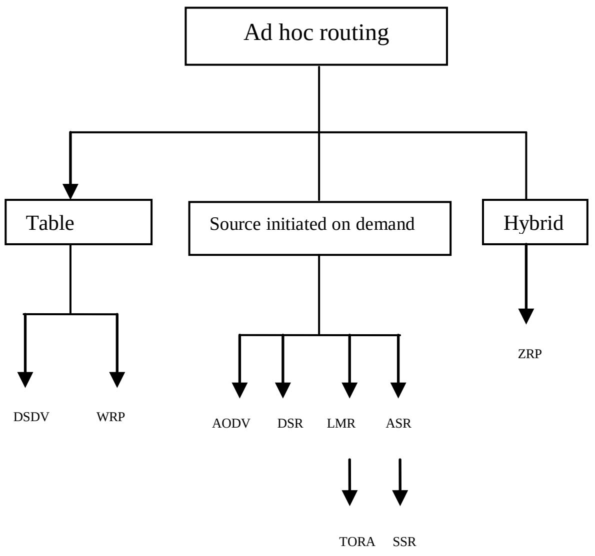

Figure 1. Classification of ad hoc routing protocol

3. ROUTING LIFE TIME PREDICTION ALGORITHM

Since a route consists of multiple links in series, it is said to be broken if any single link among its links is broken, and thus the lifetime of the route becomes the minimum lifetime of all links in this route [1].

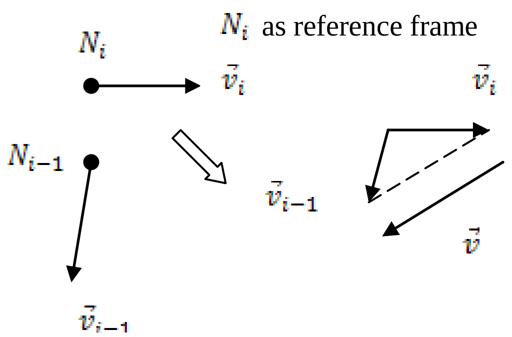

Figure 2. Relative Motion

A link is formed by two adjacent mobile nodes, which have limited battery energy and can roam freely, and it is broken if any of the two nodes is not alive due to exhaustion of energy or if these two nodes move out of each other's communication range. We use the connection lifetime and the node lifetime to distinguish the two cases described above. The connection lifetime is described as LLT in [8]. In this paper, a link is composed of the two nodes in a connection and the connection itself, and the LLT includes both the node lifetime and the connection lifetime.

A link Li consists of a connection Ci and two nodes (N_{i-1},Ni), where Ci represents the connection between nodes $N_{i-1}$and Ni, and it is maintained until the adjacent nodes (N_{i-1},Ni) move out of each other's communication range under the assumption of no energy Problem in both nodes $N_{i-1}$and Ni. We introduce connection lifetime TC_i to represent the estimated lifetime of the connection Ci, and it only depends on their relative mobility and distance of nodes $N_{i-1}$and Ni at a given time. The term TN_i denotes the estimated battery lifetime of node Ni. Then, the lifetime of the link Li is expressed as the minimum value of (TC_i,TN_{i-1},TN_i), i.e., TL_i = min (TC_i, TN_{i-1}, TN_i).

Take as an example a route P consisting of n links. Route P is said to be broken if any one of the following cases occurs. First, any one of the nodes in the route dies because of limited battery energy. Second, any one of the connections is broken because the corresponding two adjacent nodes move out of each other's communication range. Thus, the lifetime of route P is expressed as the minimum value of the lifetime of both nodes and connections involved in route P. Assume that Ω represents the set of all nodes in route P and that Ψ is the set of all the connections in route P. Thus, the lifetime Tp of route P can be expressed as

Tp = min (TN_i,TC_i)

3.1 Methodology

From Xin Ming Zhang, Feng Fu Zou [1], the proposed algorithm consists of the following three phases:

Route discovery, Data forwarding, and Route maintenance, there are seven main differences between the EDNR and the AODV. First, in the EDNR protocol, every node saves the received signal strength and the received time of the RREQ packet in its local memory and adds this information into the RREP packet header in a piggyback manner when it receives the RREP for the corresponding RREQ packet to meet the requirement of the connection lifetime-prediction algorithm. Second, node agents need to update their predicted node lifetime during every period. Third the node-lifetime information in the RREP packet is updated when the RREP packet is returned from a destination node to the source node.

3.2 Node Life time Prediction Algorithm

A link is composed of the two nodes in a connection and the connection itself, and the LLT includes both the node lifetime and the connection lifetime [3].

A link Li consists of a connection Ci and two nodes (N_{i-1}, N_i).

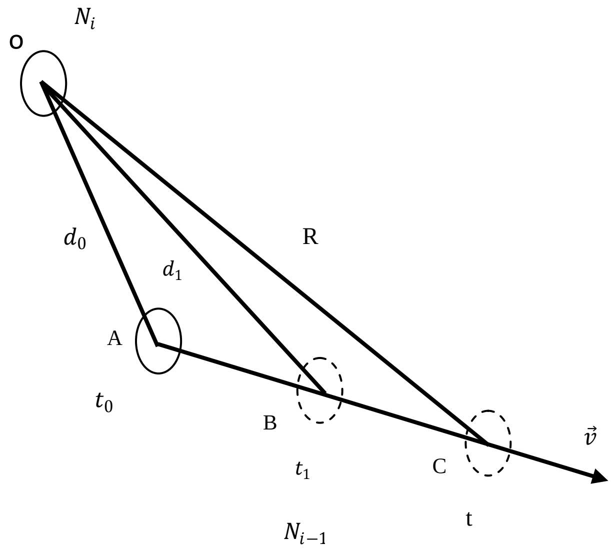

Figure 3. RREQ control message format of LEDNR

4. EXPLORING DYNAMIC NATURE ROUTING PROTOCOL

From Xin Ming Zhang [1], first in the EDNR protocol, every node saves the received signal strength and the received time of the RREQ packet in its local memory, and adds this information into the RREP packet header in a piggyback manner when it receives the RREP for the corresponding RREQ packet to meet the requirement of the connection lifetime-prediction algorithm. Second, node agents need to update their predicted node lifetime during every period. Finally, the node-lifetime information in the RREP packet is updated when the RREP packet is returned from a destination node to the source node. At every EDNR node agent, a variable NLT, which represents the node lifetime, is added to represent the estimated lifetime of this node and it is updated by the algorithm [7].

For the lifetime of a link Ci, there are two sample packets exchanged between nodes$N_{i-1}$and Ni (packet 1: N_{i-1} RREQ $\rightarrow N_i$ packet 2: N_{i-1} RREP $\rightarrow$ N_i) in the route-discovery phase, and thus, we can estimate the LLT using the proposed algorithm presented in Section [7]. To implement this, every node agent needs to maintain a data structure called RREQ _Info table in its local memory. This structure includes the RREQ id, the forwarding RREQ time, and the RREQ received signal strength. For a path sequence S, . . . , N_{i-1}, N_i, N_{i+1}, . . . , D, when an intermediate node Ni receives an RREQ packet from N_{i-1}, it adds this RREQ id, the current time, and the received signal strength to its RREQ _Info table before it continues to forward this RREQ packet. Similarly, N_{i+1} node saves the RREQ _Info from node Ni in its local memory. In the returning RREP period, when node N_i receives an RREP packet from nodeN_{i+1}, the RREQ _Info from N_i (information of Ni RREQ N_{i+1} has been added to the RREP header by N_{i+1} before node N_{i+1} sends an RREP packet to nodeN_i. Simultaneously, node Ni knows the RREP time and the RREP received signal strength from node N_{i+1} (information of N_i RREQ N_{i+1}). Thus, it can obtain the second sample packet that is delivered between the corresponding two nodes (N_i,N_{i+1}), and, thus, we can calculate the connection time TC_i using the connection lifetime-prediction algorithm and then update the local LLT value. Similarly, node Ni should add the RREQ _Info entry that is received from node N_{i-1} to the RREP header before sending the RREP to node N_{i-1} and then node N_{i-1}calculates the LLT between nodes (N_{i-1}, N_i).

Three new entries, i.e., path lifetime (PLT), RREQ time, and RREQ signal strength, are added to the common header of an RREP packet. The PLT represents the predicted lifetime of the source route in this packet header and can be updated when RREP packets are forwarded from the destination node to the source node in the route-discovery phase. The RREQ time and the RREQ signal strength represent the RREQ _Info of the previous RREQ node. The EDNR node agent only updates the PLT value in the common header of the RREP packet with a local NLT value or LLT value, if NLT < PLT or LLT < PLT, before forwarding this RREP packet. When this RREP packet reaches the source node, the PLT becomes the minimum value of the estimated lifetime of all nodes and links through the route from the source node to the destination node. In the persistent data forwarding period, a source node tends to select the path with the longest lifetime (the path with the maximum PLT value) from multiple paths as a source route for data forwarding.

5. PESR PROTOCOL

5.1 Existing Power effective Routing Protocols:

Conserving power and carefully sharing the cost of routing packets will that node and network life are increased ensure.

There are some energy efficient routes:

1. Minimize Energy Consumed/Packet:

This is one of the most obvious metrics that reflects our intuition about conserving energy. Assume that some packet j traverses nodes n1, n2, n3...nk where n1 is the source and nk is the destination. Let T (a,b) denote the energy consumed in transmitting and receiving one packet over one hop from a to b. Then the energy consumed for packet j is: ej = (i=1 to i=k-1)∑T(ni, ni+1).

Thus the goal of this metric is to, Minimize ej, for every packet j.

2. Maximize Time to Network Partition:

This metric is very important in mission critical applications such as battle site networks. Unfortunately, optimizing this metric is very difficult if we need to simultaneously maintain low delay and high throughput.

3. Minimize Variance in Node Power Levels:

The intuition behind this metric is that all nodes in the network are equally important and no one node must be penalized more than any of the others. This metric ensures that all the nodes in the network remain up and running together for as long as possible.

4. Minimize Cost/Packet:

The paths selected when using metrics should be such that nodes with depleted energy reserves do not lie on many paths. Let fi(xi) be a function that denotes the node cost or weight of node i. xi represents the total energy expended by node i thus far. We define the total cost of sending a packet along some path as the sum of the node weights of all nodes that lie along the path. The cost of sending a packet j from n1 to nk via intermediate nodes n2......., nk-1 is: cj=fi (xi), the goal of this metric is to minimize cj, every packets j

5. Minimize Maximum Node Cost:

Let Ci (t) denote the cost of routing a packet through node i at time t. Define: C` (t) denote the maximum of the Ci (t) s. Then: Minimize C` (t), every t > 0

6. AN EFFICIENT POWER EFFECTIVE SOURCE ROUTING PROTOCOL (PESR):

Energy conservation for a mobile device can be done either in transmission mode or in idle mode. There are two ways to reduce power consumption in transmission mode,

1. Using a proper route and power to transmit.
2. Reducing routing overhead by increasing cache efficiency.

I present a power effective source routing protocol called PESR based on the Dynamic Source Routing with the objective to maximize the system life time of MANET and delivery rate.

6.1 Routing Discovery Algorithm

From AshutoshSingh, PESR Protocol [11], the route request and route reply packets of DSR protocol.

Two fields are added in route request and route reply packet: Total-cost field contains the cost of the route started from the

source; Tx-power field contains proper transmission power which is needed from previous node to this node

1. The Source node initiates the connection by flooding the network in the direction of destination node. It also sets the cost field to zero before sending the request i.e. Cost (Nr) =0.

2. Every intermediate node, which has energy greater than threshold value Te, only forwards request to the neighbor within its range.

3. On receiving the request every intermediate node starts a timer Tr, computes metric and is added to the total cost of the path as mini-cost. Thus if the request is sent from node Ni to nodeN_j, that N_i calculates the cost of the path as Cost (N_j) = Cost (N_i) + metric (N_i,N_j).

4. If additional RREQ's arrive with same destination and sequence number then the cost of the newly arrived RREQ packet is compared to the mini-cost. If the packet has a lower cost, min cost is changed to this new value and the new RREQ packet is forwarded otherwise RREQ packet is discarded.

5. Transmit power is also added to request packet, which is computed by using received signal strength.

6. The destination waits Tr of seconds after the first RREQ packet arrives. During that time the destination examines the cost of the route of every arrived RREQ packet. When the timer Tr expires the destination node selects the route with minimum cost.

7. If two or more paths same cost value, the one received first is preferred. Then the destination initiates route reply packet with same contents of RREQ packet and replies it to the source along the reverse path.

8. Every node in route reply (route request) adds this Route and the value of needed transmission power to this neighbor in this cache table.

Table 1. Simulation Parameter

Simulation Time	1000 s
Topology Size	1000m 1500m
Number of nodes	100
MAC type	MAC 802.11
Radio Propagation Model	Two ray Ground
Radio Propagation Range	250 m
Pause time	0 s
Max speed	4m/s – 24m/s
Energy model	Energy model
Initial Energy	100 J
Transmit power	0.4 W
Received Power	0.3 W
Idle Power	0 W
Traffic Type	CBR
CBR Rate	512 Bytes x 6 per second
Max No. of Connection	50

7. SIMULATION RESULTS

Our implementation is based on network simulator nam v1.10; the mobility of nodes follows a random way-point model. The source–destination connection patterns are generated using cbrgen.tcl in NS-2. The initial energy is the 100 joules and simulation time is set to 1000 s in the simulation, we consider a total of 100 nodes initially randomly distributed over a square network of size1000m × 1500m. Every node moves at a speed V and transmits at uniform power of coverage of radius under certain traffic load. Three different transmission ranges {150, 200, 250} are covered, all within the coverage. Four different speeds {5, 10, 15, and 20} are simulated, from lower mobility to higher mobility scenarios. Traffic, supplied from a CBR source with fixed packet size of 1000 Bytes, is randomly generated with uniformly distributed sources and destinations. Different number of traffic flows {5, 10, 15, and 20} is simulated as appendix [1], covering low and moderate flow configuration.

7.1 Simulation Graphs

7.1.1 Packet Delivery Ratio

$$PDR = \frac{TOTAL\ No.\ OF\ PACKETS\ SUCCESFULLY\ DELIVERED}{TOTAL\ NUMBER\ OF\ PACKET\ SENT} \text{ x } 100\%$$

Packet Delivery Ratio (PDR) is calculated by dividing the number of packets received by the destination through the number of packets originated by the source.

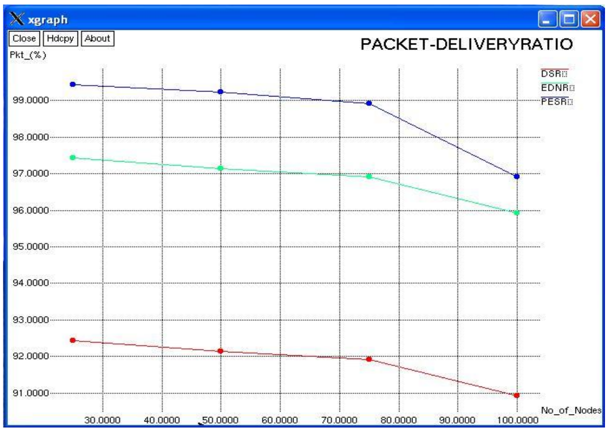

Figure 3. this result shows us that PESR has a increase the packet delivery fraction than the DSR & EDNR protocols

7.1.2 End-End Latency

End-End latency measures the average time it takes to route a data packet from the source node to the destination.

it is expressed as

$$LATENCY = \frac{\sum INDIVIDUAL\ DATA\ PACKET\ LATENCY}{TOTAL\ NUMBER\ OF\ PACKET\ DELIVERED}$$

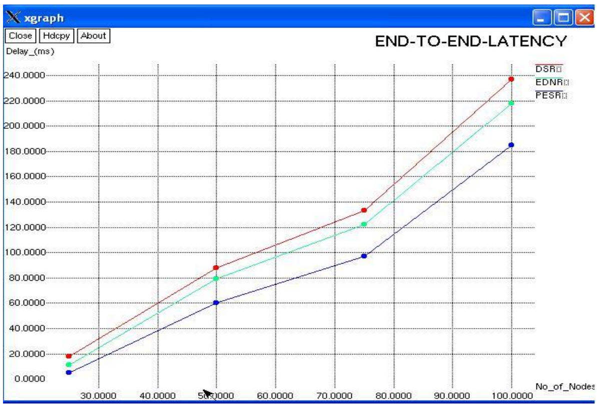

Figure 4. This result shows us that PESR has a low Delay than the DSR & EDNR protocols.

7.1.3 Energy Consumption

These measures the energy expended per delivered data packet. It is expressed as

$$E_n = \frac{\sum ENERGY\ EXPENDED\ BY\ EACH\ NODE}{TOTAL\ NUMBER\ OF\ PACKET\ DELIVERED}$$

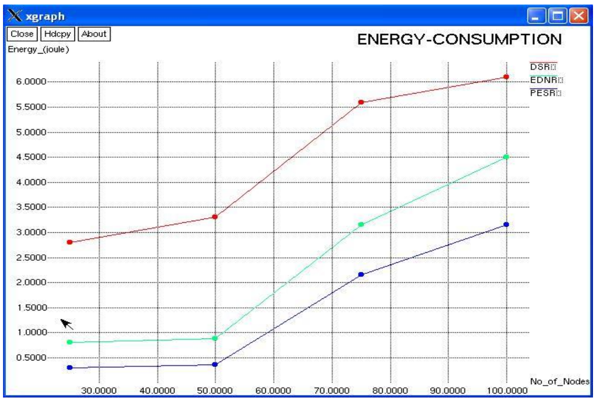

Figure 5. This result shows us that PESR has a lesser energy consumption than the DSR & EDNR protocols.

7.1.4 Throughput

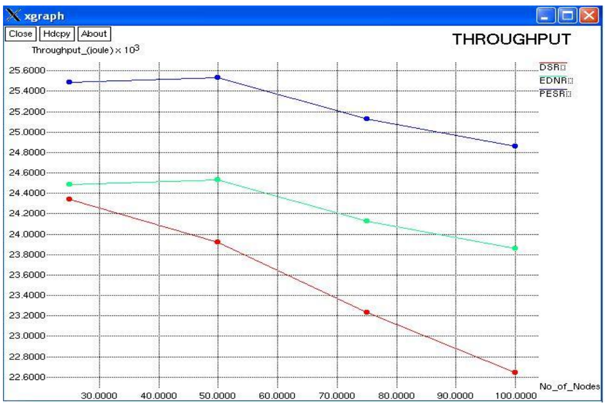

Figure 6. This result shows us that PESR has a high Throughput than the protocols DSR & EDNR

8. CONCLUSION

In MANET, a link is formed by two adjacent mobile nodes, which have limited battery energy and can roam freely, and the link is said to be broken if any of the nodes dies because they run out of energy or they move out of each other's communication range. In this paper, we have considered both the node lifetime and the LLT to predict the route lifetime and have proposed a new algorithm that explores the dynamic nature of mobile nodes, such as the energy drain rate and the relative motion estimation rate of nodes, to evaluate the node lifetime and the LLT. Combining these two metrics by using our proposed route lifetime-prediction algorithm we can select the least dynamic route with the longest lifetime for persistent data forwarding. Finally, we have evaluated the compare performance of the proposed EDNR and PESR protocol based on the DSR. And finally we achieved the better performance through the PESR protocol.

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