Energy Efficient Routing in Mobile Adhoc Network

Atul Shintre
Student, M.E. I.T. V.E.S.I.T

Shanta Sondur
Professor, V.E.S.I.T. Chembur.

ABSTRACT
Routing is one of the key issues in Mobile Adhoc Network. Although establishing correct and efficient routes is an important issue in MANETs, a more challenging goal is to provide energy efficient routing protocols since mobile nodes will be powered by batteries with limited capacity. 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. On demand routing protocols such as AODV and DSR for MANETs are known to use low bandwidth and consumes less power which makes them appealing for MANET's scenario. This paper discuss and evaluate energy efficient AODV routing protocols in which some nodes remain silent without forwarding the redundant rebroadcast packets.

General Terms
Mobile Adhoc Network (MANET), Routing, Packets.

Keywords
Energy efficient routing, Mobile Ad-hoc Networks (MANETs), Ad-hoc On-demand distance vector routing protocol.

1. INTRODUCTION
Networks are classified in two main types, wired networks and wireless networks [1][2][3]. A wireless network provides the flexibility to its users, to retrieve the information and get services even when they are travelling. Wireless networks are majorly classified as, single–hop and multi-hop Mobile Ad-hoc Networks (MANET). In single-hop wireless networks to accomplish the communication between mobile nodes base stations are used. Multi hop MANETs are the infrastructure –less, self organizing networks of mobile nodes with no centralized administration. In MANETs the routing among mobile nodes take place through intermediate nodes, so every node acts as a host as well as a router in MANETs. And hence routing protocol plays a major role in MANET.
In MANETs, the routing protocols are mainly classified using their routing strategy used and the structure of network. Based on the network structure protocols are classified as flat routing, hierarchical routing and geographic position based routing. Based on the routing strategy protocols are classified as table driven and source initiated on demand routing protocols. Table driven routing protocols uses proactive strategy to find the routes and maintain them in routing table, lots of packet routing overhead take place in finding the routes for all source- destination pair. On- demand routing protocols such as AODV[14] and DSR uses reactive strategy[15] to find path between sources – destination pair, only when it is requested by the source, so incur a less overhead of packet routing. Compared to table driven protocols, on –demand protocols utilize less bandwidth and consumes less energy.
Since on-demand routing protocols such AODV (ad hoc on demand distance vector) and DSR (dynamic source routing) use the simple flooding method to find a route to the destination , the number of route request (RREQ) packet needs to rebroadcast across the network. Energy efficiency is a major issue in MANETs, processing of such RREQ packets again and again by same node consumes more power. So, to control the network wide broadcast of RREQs, the source node uses the Expanding Ring Search (ERS) technique, which allows a source node to broadcast the RREQ increasingly to larger areas of the network if the route to destination is not found. Unfortunately, some node in ERS technique rebroadcast the RREQs unnecessarily. This paper discuss the energy efficient design of AODV routing protocols in which some nodes remain silent without forwarding the redundant rebroadcasting of the RREQ packets .
The rest of the paper is organized as follows, Section 2 describes the Energy efficient routing protocols, and Section 3 explains performance measurement parameters. Section 4 discusses comparative result analysis of energy efficient routing protocols, and section 5 conclusion and Future Scope.

2. ENERGY EFFICIENT ROUTING PROTOCOLS
Ad hoc on demand distance vector (AODV) routing protocol finds the routes between source and destination when the source needs to send a packet to destination. Traditional AODV broadcast RREQ packet to entire network, every node in the network receive and process the packet. The nodes that receive the RREQ (route request) packet for the first time check for the route in routing table. If the route to destination is available then RREP (route reply) packet is unicast to source, else it will rebroadcast RREQ to the neighbors. When the source gets the RREP, it starts the communication and maintains the route as long as it is needed.

2.1 Expanding Ring Search Technique [6][8]
As in AODV, the source node broadcasts the RREQ packet to its neighbor which in turn forwards the same packet to their neighbor and so forth in finding the route. Especially for the large network there is need to control the network wide broadcast of such RREQ packets, to control the same source node uses the Expanding Ring Search technique[4][5][6]. In this technique the source node sets the TTL (Time to Live) value in RREQ packet to an initial value. If there is no reply within the route discovery period, the next RREQ packet is forwarded with the increased TTL value by some increment value k. The process of incrementing TTL value continues until the TTL value reaches some Threshold value, after which the RREQ is broadcasted to entire network.

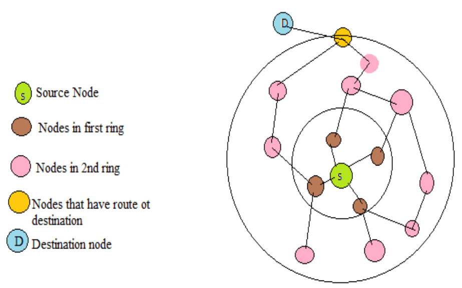

Figure 1 : Example of Expanding Ring Search Technique.

In this example, the source node S wants to find the route for the destination node D. Source node uses the expanding ring search technique to find the route for D. Initially S starts with TTL value with 1 and forms the first ring as you can see in fig. The node in the first ring does not have the information about the D, so after expiry of the route discovery period, the source node again sends the RREQ packet with increased TTL value. The TTL value for 2nd ring is 3, and some nodes in 2nd ring have route to D, and those nodes unicasts the RREP (route reply) to source node. This process continues until the destination found.
The ERS method has some drawbacks. If the network is wide and the destination node is far from the source node, then in such case the source node has to broadcasts the RREQ packets multiple times, and the intermediate nodes have to receive and process the same packets again and again, to overcome such issues a new approach is given.

2.1 Efficient Expanding Ring Search [EERS] Technique

As in above ERS technique, when a node broadcasts the RREQ packet to its neighbor, that neighbor receive and process the packet if is received for the first time and again rebroadcast the same packet to its neighbor otherwise that packet will be dropped. However, if the message contains the information regarding senders, such as node's ID, sequence number that will be wasted when such packets are dropped. This information is used by the neighbors to decide whether to remain silent or participate in relaying the packet. This new approach is known as the Efficient Expanding Ring Search (EERS) [4][5][6] Technique. As we have seen, in ERS every node relaying the incoming message but in EERS, some nodes participate in relaying the message and some remains silent based on the nodes information received in packet.
In EERS technique, the state of the node is determined as" relaying" or "silent" based on the "Relay" variable in each node . If the value of the "Relay" variable is "true" then that node is in relaying state. This value of the "Relay" variable is determined from the incoming packet which contains entries for the predecessor node. For example, if node 1 sends message to node 2, and node 2 in turn sends message to node 3 then node 1 becomes predecessor for node 3.The value of the predecessor at the source node is same to its address only and at the intermediate node that value is the senders address. EERS has mainly two phases; first phase is *collecting the neighbor's information* (CNI) and second is the *reducing the overhead of flooding* (ROF).
In the CNI phase, every node broadcast the packet without considering the value of the "Relay" variable. The value of Relay variable is set to "true" or "false" after completion of first phase, and it will be used by the node in the second phase to decide whether to broadcast the packet or not. If the value of the "Relay" variable is "false" after the first phase then that node is in the silent state and preserve the energy.

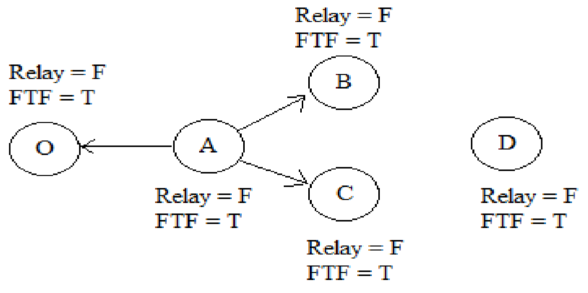

Figure 2: Route Request broadcast by node A.

The phase of the node is determined using the variable "FTF" (First Time Forward).If the value of the FTF is "true" then that node is in CNI phase; otherwise it is in ROF phase. Initially the value of FTF for all nodes is "true", means all the nodes are collecting the neighbor's information and after broadcasting the message it is set to "false". For example, when the source node broadcast the message to its neighbor and if these neighboring nodes are processing the message for the first time, they re-encapsulate the message with predecessor value as the senders address, broadcast the message to its neighbor and set the FTF value to "false". If the sender gets that broadcast message second time, it will check the predecessor value in the message, if the predecessor address value is same to the senders address, then that node sets Relay value to "True" and participate into finding the route , otherwise the message is discarded. So the nodes can preserve their energy by remaining silent.
When the above scheme is applied to the ERS, the Relay value of nodes which are at the border of the ring gets affected, because the position of the nodes are not fixed in MANETs and nodes moves from place to place so the topology of the network gets changed and the state of the node needs to reset after a certain interval of time. This is major issue is addressed in Energy Efficient AODV (E^{2}AODV) [7].

2.2 Energy Efficient AODV (E^{2}AODV)

In the above discussed Efficient Expanding ring search (EERS), the nodes initial value of relaying variable is "False" and it will be set to "True" only when message with TTL value greater than 2 is arrived. But when these nodes process the packet with TTL value less than 2 , they will not take part in the second search, and hence it is not much efficient in finding the route to destination. In E^{2}AODV the initial relay value is set to 1 and it is designed to handle the RREQ packets with TTL value less than 2. So the nodes those are at the border of the ring not get affected and participate in finding the route to destination.
The following steps are involved in E^{2}AODV

•Initially Relay and Forward value of all the nodes is set to 1, which means it will take part in first time forwarding of the RREQ of particular source destination pair (SD pair). Then the Relay Forward function will be called based on the TTL value of the RREQ.

• Pre-Address (P-Addr) field is added with the RREQ packet. Before initiating the RREQ, source node appends its address into its P-Add field. The intermediate nodes which are rebroadcasting the RREQ append the address of the node from which it got the RREQ packet to the RREQs P-Add field.

• The Relay value will be set to 0, when an intermediate node rebroadcasts a RREQ for particular SD pair. The Forward value will also be set to 0, but only when the TTL value of the SD pair is greater than or equal to 2. Else it will remain the same.
• When a node receives a RREQ with its address in PAdd, then the relay value will be set back to 1 which means that the particular node's RREQ packet has been used by its neighbor nodes for finding the path. Hence the node with relay value 1 will then participate in finding the route by forward the RREQ for that SD pair.

• If both the Relay and Forward are 0, then the node will not forward the RREQ for that SD pair.

• Only if the Relay value is 0, then the Relay Forward function is called depending on the TTL value.

The Expanding Ring Search techniques discussed above has some limitations. In ERS the destination is searched in multi-ring scheme instead of one to all schemes and this can be achieved by increasing the TTL value from initial value to some threshold value and expand the radius of search linearly. To overcome this issue, Blocking- ERS is designed.

2.3 Blocking – ERS

The concept used in B-ERS [4] is that, when the source node ends with the discovery of the destination, there are some nodes in the network which are processing and forwarding the messages, such nodes needs to stop from further forwarding of the packets so that the energy can be saved from further processing of the packets. To achieve this, chase packets are used. Chase packets are propagated through the network to stop the discovery of the route. At the same level the B-ERS is designed in such a way that, the search ring starts from the previous ring instead of the starting from the source node as in ERS.

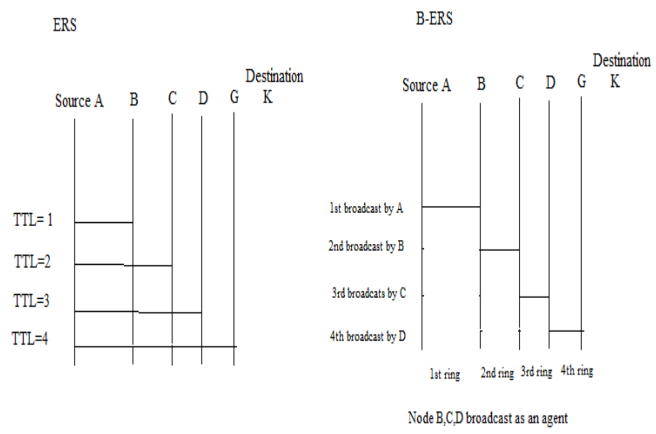

Figure 3: Example Multi-ring search in B-ERS & B-ERS+

In Blocking ERS (B-ERS) sometime fulfilled route request manages to escape from the chase packets due to the mobility of the nodes and hence the success rate degrades as chase packets are discarded. A new improvement is suggested for this known as Blocking-ERS-Plus (B-ERS+) in which chase packets is broadcasted until catching is insured to maximize the success rate.

3. PERFORMANCE MEASUREMENT PARAMETERS [8]

There are number of qualitative and quantitative parameters that can be used to compare the reactive routing protocols. The following different quantitative parameters have been considered to make the comparative study.

1) *Routing Overhead*: This metric describes how many routing packets for route discovery and route maintenance need to be sent so as to propagate data.

2) *Average Delay*: This metric represents average end-to-end delay and indicate how long it took for a packet to travel from source to the destination. It is measured in seconds.

3) *Throughput*: It can be defined as the total amount of data a receiver actually receives from sender divided by the time taken by the receiver to obtain the last packet.

4) *Packet Delivery Ratio*: The ratio between the amount of incoming data packets and actually received data packets.

5) *Energy Consumption*: This metric compares the total energy consumed by energy efficient routing protocol.

4. COMPARATIVE RESULT ANALYSIS

Table 1: Comparison of Energy Efficient Routing Protocols

Parameters	ERS	B-ERS	B-ERS+
Network Coverage in terms of catching route request packet	Not applicable as chase packets are not used.	Less compared to B-ERS+ as chase packets are forwarded in ring only	More network coverage as chase packets are broadcasted beyond the ring
End-to-End Delay	Is more as route discovery is done in multiring fashion	Less compared to ERS as the route discovery is done in one to all fashion.	Less as the network is congestion free and route discovery follows same as B-ERS
Packet loss	Is more	Less compared to ERS	22% to 55% packet loss is reduced compared to B-ERS
Routing Overhead	Routing overhead is more near about 60% to 65% compared to B-ERS and B-ERS+	Routing overhead is 10 to 15 % less than B-ERS+.	Routing overhead is 10 to 15% is more as chase packets are broadcasted beyond the ring.

5. CONCLUSION AND FUTURE SCOPE

- ❑ B-ERS deliberately delayed the route request packet i.e. 2hop-count*NTT which is more and end to end delay will be more for real time applications.
- ❑ Reliability of the algorithm is very poor. Needs retransmission for real time apps.

As the lifetime of the network is depend on the battery life of the nodes, the design of energy efficient routing protocols is must. The main motive of this paper is to discuss the energy efficient routing protocols their pros and cons and find out the possible improvements in this protocols, by analyzing the comparison points of above discussed protocols we have concluded with following improvements in protocols which lead for the future work.

Optimized and Reliable B-ERS
Implementing the retransmission mechanism in B-ERS that will ensure the Reliability of the protocol

Improved B-ERS
B-ERS deliberately delayed the route request packet with a delay of 2hop-count*NTT (Node Traversal Time) which can be reduced by half percent so that end-to-end will be reduced.

6. REFERENCES

[1] Hui Xu,Student Member,IEEE, Xianren Wu,Member,IEEE,Hamid R.Sadjadpour,Senior Member,IEEE,and J.J. Garcia-Luna-Aceves,Fellow,IEEE "A Unified Analysis of routing Protocols in MANETS "IEEE TRANSACTIONS ON COMMUNICATIONS,VOL.58 NO.3.MARCH 2010

[2] Dinesh singh, Deepak Sethi, Pooja "Comparative Analysis of Energy Efficient Routing Protocols in MANETS (Mobile Ad-hoc Networks) " International Journal of Computer Science and Technology. Vol.2,Issue3,September 2011

[3] Sunil Taneja and Ashwani Kush " A Survey of Routing Protocols in Mobile Ad Hoc Networks " International Journal of innovation ,Management and technology,Vol.1,No.3,August 2010 ISSN:2010-0248.

[4] MznahAl-Rodhaan,lewis Mackenzie,Mohamed Ould-Khaoua " Efficient Expanding Ring Search for MANETs " International Journal of Communication Networks and Information Security (IJCNIS) Vol.2,No.3,December 2010

[5] Duy Ngoc Pham , Van Due Nguyen,Van Tien Pham,Ngoc Tuan Nguyen,Xuan Bac Do,Trung Dung Nguyen Claus Kuperschmidt,Thomas Kaiser " An Expending Ring Search Algorithm For Mobile Adhoc Networks " IEEE The 2010 International Conference on Advanced Technologies for Communications.

[6] Dug Ngoc pham,Hyunseung Choo " Energy Efficient Ring Search for Route Discovery in MANETs", IEEE The 2008 International Conference on Communications.

[7] S.preethi , B.Ramachandran " Energy Efficient Routing Protocols for Mobile Adhoc Networks" 978-1-4477-0240-2/11/$26.00 2011 IEEE.

[8] Woonkang Heo,Minseok Oh " Performance of Expanding Ring Search Scheme in AODV Routing Algorithm " IEEE 2008 Second International Conference on Future Generation Communications and Networking.

[9] LI Shibao,JIA Wei " AODV Route Protocol Research Based on Improved ERS Algorithm " 978-1-4222-5849-3/10/$26.00 2010 IEEE.

[10] Jinhua Zhu and Xin Wang ,Member IEEE " Model and Protocol for Energy –Efficient Routing over Mobile Ad Hoc Networks " IEEE TRRANSACTIONS ON MOBILE COMPUTING. VOL.10,NO.11,NOV.2011

[11] Chansu Yu,Ben Lee, Hee Yong Youn " Energy Efficient Routing Protocols for Mobile Adhoc Networks " This research was supported in part by the Cleveland University,EFFRD No.0210-0630-10.

[12] Joo-Han Song , Student ,IEEE, Vincent W.S.Wong,Member ,IEEE,and Victor C.M.Leung,Fellow,IEEE. " Efficient On –Demand Routing for Mobile Ad Hoc Wireless Access Networks " IEEE Journal On Selected Areas in Communications ,Vol.22,No.7,September 2004.

[13] Sapna S. Kaushik,P.R.Deshmukh, " COMPARISON OF EFFECTIVENESS OF AODV,DSDV AND DSR ROUTING PROTOCOLS IN MOBILE AD HOC NETWORKS" International Journal of Information Technology and Knowledge Management ,July-December 2009,Volume 2,No.2,pp.499-502.

[14] C.Perkins ," Ad hoc on –demand distance vector(AODV) routing :,RFC 3661, July 2003

[15] D.Johnson,"The Dynamic Source Routing Protocol (DSR)", RFC4728, Feb2007.