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Avoiding Low Energy Routing Node in MANET Based on Critical Energy Level

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Abstract

Mobile ad hoc network is a temporary wireless network consisting of mobile nodes. Frequent route breakage is a common event in MANET. Every node is equipped with battery energy. This form of energy is one of the scarce resources in MANET. This paper is focused on promiscuous mode to observe packets coming from the nodes within a direct transmission range. At the same time critical energy level of a routing node is used to find the low energy node on an ongoing route. This low energy node will perform local route repairing scheme such as QLR-APM to find alternate node of low energy node which avoids route breakage in MANET. This approach prevents route breakage and at the same time packet loss and retransmission of packets are reduced in MANET. Thus it is easily seen that QLR-APM incorporating this proposed approach outperforms than QLR-APM.

Keywords: Mobile Ad Hoc Network, Routing Protocol, Critical Energy Level, and Promiscuous Mode

I. Introduction

Mobile ad hoc networks (MANETs) are infrastructure-less, self-organizing and rapidly-deployable temporary wireless networks. Every node in MANET is mobile hence dynamic in nature and topology may change frequently[1]. All the nodes of MANET get power from battery with limited capacity. A node can act both as a host and a router in MANET[2]. A node can directly communicate with a node if it is in transmission range of first one. A node cannot communicate directly with others which are out of transmission range. When two nodes are out of transmission range they need help from other intermediate nodes to forward packets between them. In MANET nodes communicate from any sources to any destinations using a route. A route is a path from the source to the destination. Routing protocol gives different routes from source to the destination. There are mainly two different types of routing protocols which are proactive routing protocols and reactive routing protocols. The main difference between these two types of protocols is how and when these two different types of protocols discovers and maintains routes. Proactive routing protocol keeps all routes from all the sources to the destinations always in a table. If any changes are occurred in the network periodic broadcasting updates all the necessary changes in the table. Example of proactive routing protocol is Destination-Sequenced Distance-Vector Routing (DSDV)[3]. Reactive routing protocols find route only when necessary to communicate with a particular destination. Source node applies route discovery mechanism of reactive routing protocol to find all available routes from the source to the destination. Source node then selects one route from its cache to communicate with particular destination. All the other routes are alternate routes which are kept into source's cache for future uses if the primary route fails. Examples of reactive routing protocol is Ad Hoc on Demand Distance Vector Routing (AODV)[4]. There is also hybrid routing protocol such as Zone Routing Protocol (ZRP)[5]. In ZRP for intra-zone routing proactive routing protocol is used and for inter-zone routing reactive routing protocol is used. In Figure 1, a route A-B-C-D-E is shown and all nodes' transmission ranges are shown using dotted circle. In this case node A can directly send packets to node B but not to node C. Suppose node A is communicating with node E by using this route. C's energy is reduced to critical energy level[6] and if node C is continuing to send packets of node A then node C will die out soon and many packets may loss. To avoid this low energy node this paper is presenting a scheme which discovers a node to replace the low energy node C from the local zone before occurring any route breakage. By using the proposed scheme in Figure 2, node C can be replaced by node F without any route breakage. In the proposed approach there is no route breakage event but in advance the low energy node is replaced to avoid route breakage and packet losses.

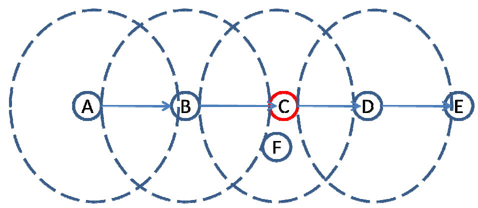

Fig. 1. A MANET scenario

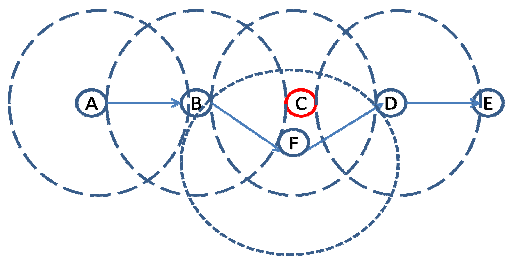

Fig. 2. New route possible using F

The rest of the paper is organized as follows. Section II reviews related work, in section III proposed scheme is described, section IV illustrates the performance evaluation and finally conclusion is drawn in section V.

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II. Related Work

Local route repairing is useful to recover route from the error zone where route breakage occurs. There are some schemes which already exists in local route repairing such as Ad Hoc On Demand Distance Vector-Backup Routing (AODV-BR)[7], Witness Aided Routing (WAR)[8]. AODV-BR[7] assumes all nodes in the network keep them in promiscuous mode to overhear packets transmission from others within the range and consuming excessive energy from the network. WAR[8] also allows nodes to operate in promiscuous mode. These mentioned schemes suffer from excessive energy consumption, long delay etc. A very good approach named quick local repair scheme using adaptive promiscuous mode (QLR-APM)[9] is also proposed to mitigate long delay and excessive energy consumption from the network. But this approach starts route repair process after any route breakage event. Thus some packets will loss in QLR-APM[9]. In order to reduce packet losses in this paper a scheme is proposed. This scheme is based on the critical energy level[6] of a node and applying QLR-APM[9] to change the low energy node from the current primary route. This way route breakage in the MANET caused by the low energy node is prevented.

Quick local repair scheme using adaptive promiscuous mode (QLR-APM)[9] is used to repair route error locally in the local zone where route error occurs. This approach is divided into two parts which are adaptive promiscuous mode and quick local repair scheme.

A. *Adaptive Promiscuous Mode*

A node in promiscuous mode keeps it receiver on to overhear packets transmission from other nodes within the same transmission domain. According to (QLR-APM)[9] a node starts its operation in promiscuous mode. After 0.5s it will check if it meets condition of promiscuous mode. If it meets it put into promiscuous mode. If it does not meet it changes to non-promiscuous mode. After 0.5s it will put into again promiscuous mode. This is called adaptive promiscuous mode. This approach ensures that a node will continuously put into promiscuous mode whenever it satisfies the any of the followings:

1. Node is overhearing three adjacent nodes on an ongoing route.
2. Node is overhearing two neighbours on an ongoing route and their TTL difference must be greater or equal two.

These scenarios are depicted in Figure 3. In Figure 3(a) node P in promiscuous mode for nodes E, F, and G. In Figure 3(b), node Q maintains promiscuous mode for node E, G and their TTL difference. The node in promiscuous mode create and maintain a table consisting of source IP address, destination IP address, neighbor address and TTL which is shown in Figure 4.

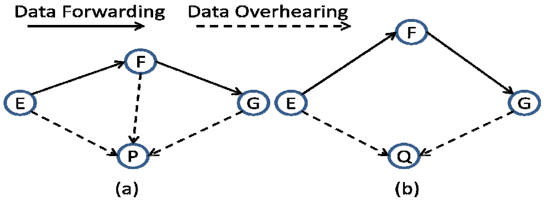
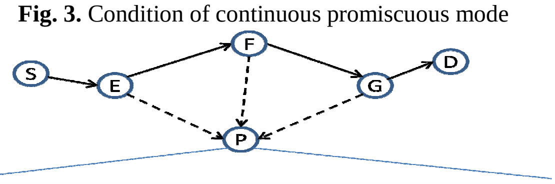


Fig. 3. Condition of continuous promiscuous mode

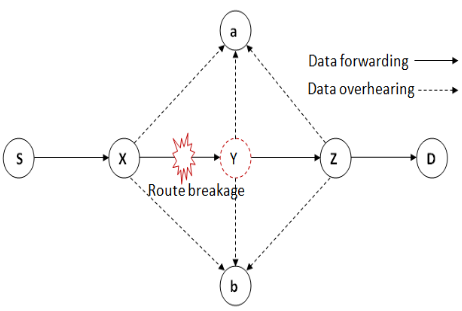


Source IP address	Destination IP address	Neighbor address	TTL
S	D	E	32
S	D	F	31
S	D	G	30

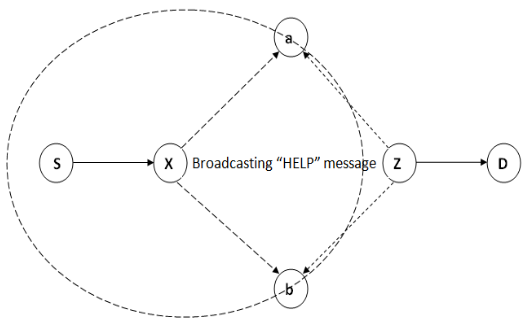
Fig. 4. Table maintain by P

B. *Quick Local Repair Scheme*

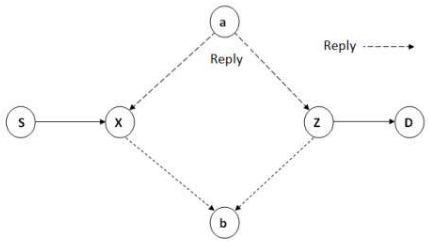
Local route repair process of QLR-APM[9] consist of four parts which are route error detection, sending HELP message to overhearing nodes, receiving REPLY message from overhearing nodes, and finishing route repair process. This process is graphically depicted in Figure 5. In Figure 5(a), S-X-Y-Z-D is a primary route, nodes a, and b are operating in promiscuous mode, and S is a source and D is a destination node. A route breakage between X and Y is detected by X which is shown in Figure 5(a). In Figure 5(b), node X then broadcasts a HELP message. Node a is replying to X and Z in Figure 5(c). Finally a new route S-X-a-Z-D is locally reconstructed using overhearing node a in Figure 5(d).



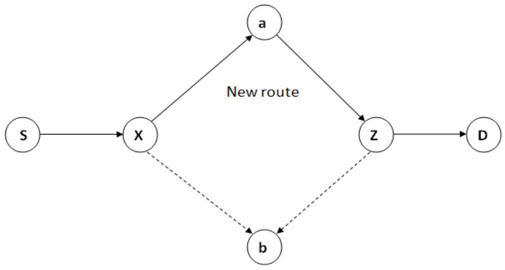
5(a) Route error detection



5(b) Sending Help Message



5(c) Reply message received



5(d) A new locally reconstructed route

Fig. 5. QLR steps to repair route locally

It is easily seen in QLR-APM, route repair process is started only after any occurrence of route breakage event. This is the limitation of this approach. When route breakage is occurred packet transmission is interrupted, some packets are lost and finally packets retransmissions are required. Route breakage is happened only for two reasons in MANET one is mobility and another is energy shortage of a node. For second reason, there is a chance to reconstruct route locally before energy shortage of any ongoing node and any route breakage occurrence. By using the critical energy level of a node to determine the time when route repair process of QLR-APM will be performed. Critical energy level C_e is defined as 10% of its full energy F_e[6]. This can be shown by the following equation:

$$C_e = 0.1 * F_e \quad (1)$$

A node whose energy equals to C_e it can be marked as the low energy node in the network.

III. Proposed Approach

This approach is based on applying QLR-APM to replace the low energy node with an overhearing node when a node's energy is reduced to critical energy level. An active node will check its energy in every t = 1s after 20% of its full energy whether it will reach into critical energy. Suppose a node in promiscuous mode for three consecutive routing nodes in the network. If the middle node is energy critical node, then this node can be easily replaced by the overhearing node in the network. In this way a route breakage is prevented to minimize packet losses in the network. In this case energy level of every routing node is observed by themselves which can cause route breakage in the network in near future. Suppose a routing node's energy level is too low and source does not stop sending packets in the current route. There must be a route breakage immediately since one of the low energy nodes will die out soon. That is why this low energy node should be avoided from the packet forwarding. Consider the network scenario in Figure 6, where node A is sending packets to destination node E using A-B-C-D-E route. This approach will check whether any node's energy is reduced to critical energy level. Below the proposed route repair process is described.

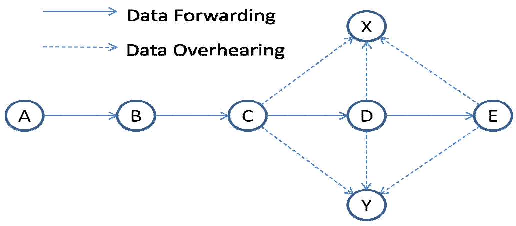


Fig. 6. Node A communicates with node E

A. Local Route Repair process

Step 1: Low energy node detection

All the routing nodes will check whether their energy level is reduced to critical energy level. Suppose energy level of node D is reduced to the critical energy level which is marked as red in Figure 7.

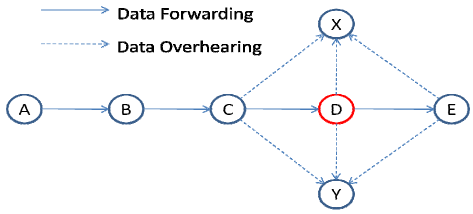


Fig. 7. D is a low energy node

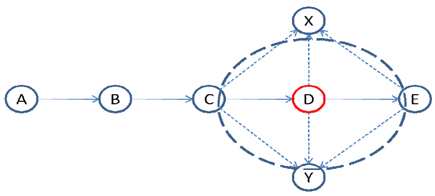


Fig. 8. Broadcasting HELP message

Step 2: Sending a "HELP" Message by low energy node

Node D will send a HELP message to the overhearing nodes X and Y which is depicted in Figure 8. This HELP message will include immediate former C and latter node E of low energy node.

Step 3: Replying to "HELP" message

Node X and Y overhear the transmission from node C and node E. In Figure 9, X and Y will send Reply message to node D, C, and E in order to replace D by X or Y.

Step 4: Finishing route reconstruction

Only the first REPLY message will be used by the local repair process.

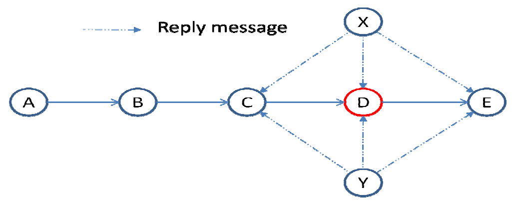


Fig. 9. Receiving Reply message from X and Y

Node D approves first REPLY message and will tell node C and E to use it in order to forward rest of the packets. Thus nodes C and E will update their routing table and will forward rest of the packets of source A through node X or Y instead of using node D. Hence new route will be either A-B-C-X-E or A-B-C-Y-E. Consider Reply message comes first from X. For this reason a new locally reconstructed route is given in Figure 10.

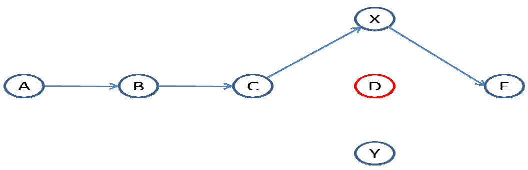


Fig. 10. Locally reconstructed route A-B-C-X-E

B. Pseudo code

The pseudo code for the proposed approach is given as follows:

Algorithm replace-low-energy-node **is**

Input: energy level of node

Output: either overhearing node or Warning message to source

(Note that HELP(n, overhearing nodes) is a HELP message from node n to the overhearing nodes, REPLY(o, n) is a REPLY message comes overhearing node o to n, Warning(n, s) is a Warning message from node n to source s, c_e is critical energy level, and first o will replace n in the route)

if energy level of node n = c_e then

send HELP(n, overhearing nodes)

if there are any overhearing nodes for n then

they will send REPLY(o, n)

using the first REPLY(o, n) only

return first replied overhearing node o

else

issue a Warning(n, s) to stop sending more

packets on the current route **endif**

else

continue sending packets using current node **endif**

C. Flow chart

This local route repair process is given as a flowchart in Figure 11.

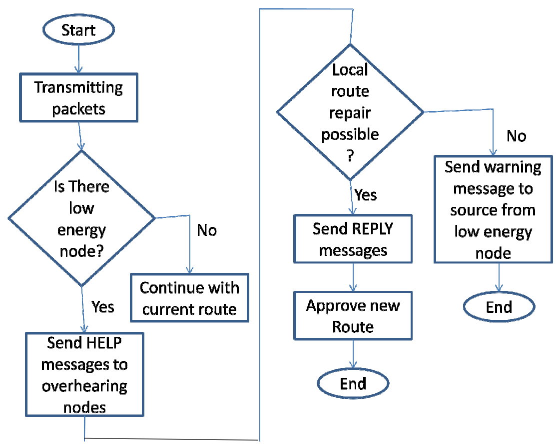


Fig. 11. Proposed route repair process

IV. Performance Evaluation

Consider the network scenario in Figure 12 where a route breakage between node E and F is occurred because of energy shortage of node F. A path is shown as A-B-C-D-E-F-G-H where A is source and H is destination node. When only QLR-APM is applied at node E it will send HELP message to the overhearing nodes and simultaneously some packets will be dropped from node E due to buffer space exhaustion which are shown in Figure 13. A new locally reconstructed route A-B-C-D-E-K-G-H is shown in Figure 14 where all the remaining packets are forwarded through node k. In Figure 15 some packets such as 7 and 8 have to retransmit by D to E. Node D would not receive any acknowledgement from node E for these packets. Thus packets loss and retransmission of packets are occurred when only QLR-APM in local route repairing is used.

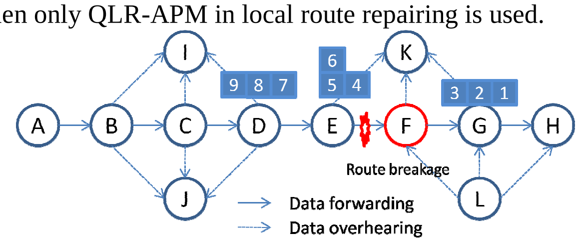


Fig. 12. Route breakage due to node F is down

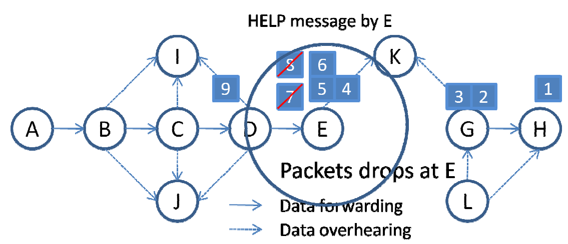


Fig. 13. Packets 7 and 8 are dropped at node E

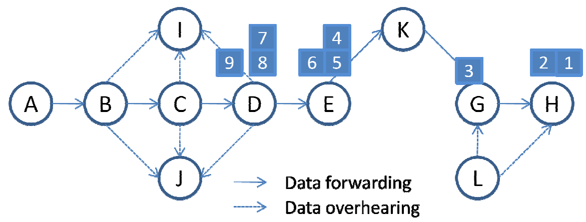


Fig 14. Route reconstructed by QLR-APM

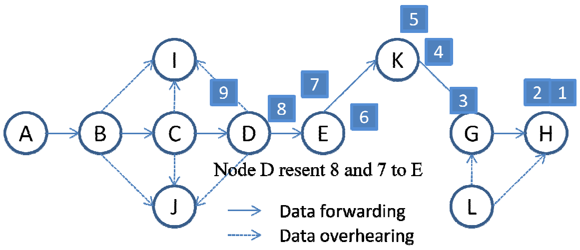


Fig. 15. Packets retransmission occurred

Let's take another network scenario in Figure 16 where there is no occurrence of any route breakage but a red colored node F is at critical energy level. According to the proposed approach this node will broadcast a HELP message to the overhearing nodes which is shown in Figure 17. Finally in Figure 18 a route is locally reconstructed using the proposed approach through overhearing node K which is A-B-C-D-E-K-G-H. In this case there is no any packet loss and hence no packet retransmissions will be required.

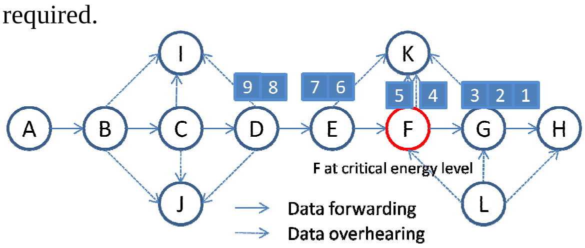


Fig. 16. Node F is low energy node

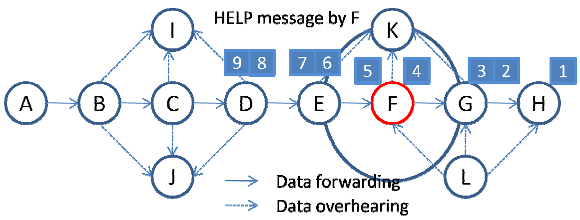


Fig. 17. F broadcasts HELP message

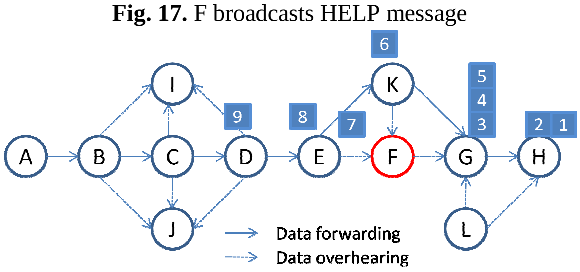


Fig. 18. A new route through K

We can summarize the result from these two scenarios specified in Figure 12 and Figure 16. Using only QLR-APM in local route repairing route breakage must occur. The consequences of this route breakage are packets losses and packets retransmission. Both of these abuses scarce network bandwidth and disrupt transmission of packets and ultimately transmission time is increased. But in the proposed approach route breakage will never occur due to energy shortage of any routing node. In advance a routing node will broadcast a HELP message before occurrence of any route breakage. And the node's remaining energy is used to forward the rest of the packets it has. In case of buffer overflow of previous node it will forward the packets to the low energy node. In this way no packets are lost in the proposed approach. Below Table 1 shows a comparison between QLR-APM and the proposed approach.

Table 1. A Comparison between QLR-APM and the proposed approach

Packets No.	QLR-APM	Proposed Approach
7, 8	Packets dropped at E in Figure 13.	No packet losses.
7, 8	Packets are retransmitted by D to E in Figure 15.	No retransmission of packets.

V. Conclusion

Sometimes there are some routes which have one or two nodes are different among the routes. In this case when route error occurs, sending route error message to source is inefficient. Local route reconstruction is effective in such case. In this paper QLR-APM is used as a local route repairing scheme when low energy node is detected. Local route repairing is called when a nodes energy level reduces to critical energy level. This low energy node will be replaced by using the any overhearing node in that region. In this paper also adaptive promiscuous mode is used as in the QLR-APM; no extra overhead is required for maintaining promiscuous mode than QLR-APM. But without route breakage proposed scheme replaces the low energy node to minimize any packet losses and packets retransmissions. Thus it is easily seen that the proposed approach outperforms than QLR-APM in case of packet losses and retransmissions.

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