Dhaka Univ. J. Sci. 62(1): 59-64, 2014 (January)

Modified QLRS-APM: A Proposal to Avoid Initiating Route Error Messages to Source in Mobile Ad Hoc Networks

Rezvi Shahariar* [1] and Shahed Anwar [2]

[1] *Institute of Information Technology, Dhaka University, Dhaka-1000, Bangladesh*

[2] *Department of Computer Science and Engineering, Dhaka University, Dhaka-1000, Bangladesh*

(Received: 20 July 2013; Accepted: 3 September 2013)

Abstract

Existing local route repair schemes such as localized route repair (LRR), ad hoc on-demand distance vector-backup routing (AODV-BR), and witness-aided routing (WAR) can be incorporated with reactive routing protocols to repair route breakages on ongoing routes. All of these schemes have some problems in local route repairing such as long delay, excessive energy consumption etc. To mitigate these problems in existing local route repair schemes, quick local repair scheme using adaptive promiscuous mode (QLRS-APM) is proposed. QLRS-APM is a novel approach in local route repairing but sometimes generates unnecessarily route error to the source. This paper provides a solution by giving an extension on QLRS-APM to avoid initiating route error messages to the source and also at the same time reducing excessive energy consumption from the network.

Keywords: Mobile Ad Hoc Networks, Routing Protocols, Local Route Repair Schemes, Promiscuous Mode

I. Introduction

Mobile ad hoc networks (MANETs) are characterized by infrastructure-less, self-organizing, rapidly-deployable temporary wireless networks. For these characteristics, MANETs are especially useful for communicating in regions where no wired infrastructure are available and can be used for emergencies, natural disasters and military operations. Each node in a MANET can act both as host and router for forwarding packets[1]. In a MANET, networks' topology changes dynamic-ally and rapidly due to node's mobility [2]. Each MANET node is powered by battery energy with only limited capacity. Power failure of a single mobile node not only affects itself but also decreases network total lifetime in forwarding other nodes' packets to destination.

Figure 1 depicts a simple MANET consisting of five nodes A, B, C, D, E and their transmission ranges are shown using circle with dotted line. Within this circle each node can directly communicate with others. One route A-B-C-D is shown from A to D where node A is a source node and node D is a destination node and all the packets use this route. If one of the node of this route fails due to power down or moving into another region, then route breakage will occur. In this case sender A has to select another route to facilitate communication with destination node D. Suppose, node B goes out of the range of node A and route breakage occurs. Figure 2 shows another route selected by node A to communicate with node D and which is A-E-C-D. It is clearly seen that there is only one hop different between these two routes used by node A and node B is replaced by the node E in the new route. These routes are obtained by running costly route discovery mechanism of routing protocols such as Dynamic Source Routing (DSR)[3], Ad Hoc On-Demand Distance Vector (AODV)[4], and Destination-Sequenced Distance Vector (DSDV) [5] etc.

Local route repairing is useful to recover route locally from the error zone without using any route discovery mechanism by the source. Because of most of the times discovered new route is almost similar to old route and only one hop is different among the two routes. Concerning this issue LRR[6], AODV-BR[7], and WAR[8] schemes are proposed and all of these try to repair the route locally but suffer from long delay, unwanted excessive energy consumption.

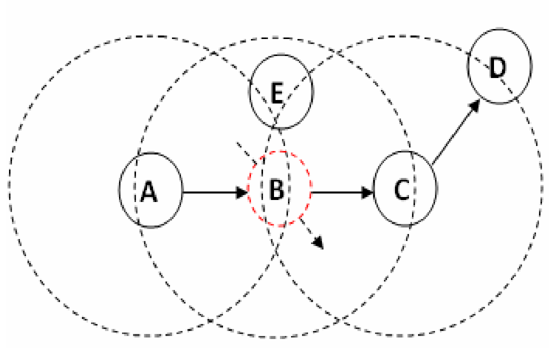

Fig. 1. A Simple MANET with five nodes

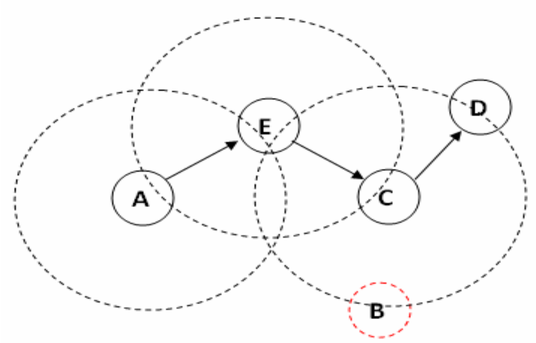

Fig. 2. Node A using another route

Quick local repair scheme using adaptive promiscuous mode (QLRS-APM)[9] is a novel approach in local route repairing and it mitigates the long delay, excessive energy consumption etc from MANETs. But it sometimes unnecessarily initiates route error message to the source from the error detecting node even if one of the overhearing nodes overhears the error node in that period of time. This paper is primarily based on reducing route error messages to the source in MANETs where there are available overhearing nodes in the error zone and at least one of the overhearing nodes overhears the error node at that time. In this case there is no need to send route error message to the

*Author for Correspondence. *e-mail*: rezvi@du.ac.bd

source but QLRS-APM sends this route error to the source blindly. As a result of this research, the source node will be less burdened and also frequent route discovery will no longer be required. Since frequent route discovery process draws excessive energy from the network and it reduces network lifetime. Thus, less energy will be consumed from the network by reducing the less number of route error message destined to the source and in this way network lifetime can be increased.

The rest of the paper is organized as follows: section II reviews related work, section III focuses on the motivation, in section IV proposal on QLRS-APM is described, section V illustrates the performance evaluation and finally conclusion is drawn in section VI.

II. Related Work

Reactive routing protocols are advantageous in case of nodes' random mobility. Most of them such as DSR or AODV have the lacking of efficient route repair algorithm. In reactive routing protocols, node that detects the route breakage sends a route error message back to the source, which induces the source node to activate the route maintenance process or in the extreme case route discovery is recalled when no route is available in cache of source node. To mitigate from this problem, there were several schemes namely LRR[6], AODV-BR[7] and WAR[8] in before to recover the disconnected route locally from the error zone in MANETs. However, all of these schemes are suffered from long delay, excessive energy consumption etc.

Quick local repair scheme using adaptive promiscuous mode (QLRS-APM)[9] is another scheme which addresses the challenge of providing quick local route repair when route error occurs. This scheme is broadly divided into two parts:

(i) Adaptive promiscuous mode (APM)

(ii) Quick local repair scheme (QLRS)

In this scheme, a node put into promiscuous mode to monitor the overheard packets to obtain the source address, destination address, next hop address, TTL and creates a table based on these information. A node is in promiscuous mode, draws excessive energy from the network and finally reduces the network efficiency which was the main drawback of AODV-BR[7]. QLRS-APM[9] selects the less number of nodes in promiscuous mode according to the following criteria:

(i) Node overhears three adjacent nodes on an ongoing route or one source-destination address pair.

(ii) Node is overhearing two neighbors on an ongoing route and the TTL difference between these two neighbors must be greater or equal two.

Initially any non-routing node put into promiscuous mode then it examines its routing table after every predefined t seconds. If it satisfies the criteria of promiscuous mode, it has to put into promiscuous mode again. Otherwise, this non-routing node will put into it in non-promiscuous mode. Nodes after non-promiscuous mode automatically put into in promiscuous mode. Every non-routing node repeats the above process and is prepared for handling a sudden route error.

QLRS-APM follows the following steps to repair broken route locally:

1. Every node tries to detect route error with the next node on an ongoing route by not receiving any ACK message after sending data or not receiving CTS message after sending RTS messages.
2. Send a HELP message by the error detecting node and the transmission will be identified by the source and destination IP address in the route.
3. All the available overhearing nodes will check whether local route repair process is possible. An overhearing node will send approval message to error detecting node and latter of error node if it knows the latter of error node.
4. Finishing the quick local route repair process.
   a. If the approval messages arrived from the overhearing nodes, then former and latter node of error node change their routing table by using the first approval message. A new route will be locally reconstructed using that overhearing node which sends the first approval message.
   b. Else the error detecting node does not receive any approval messages, it sends back a route error messages to the source node.

These steps of QLRS-APM can be shown graphically. We can consider a scenario where node p and q are overhearing nodes, S is a source node and D is a destination node and the nodes X, Y and Z are intermediate nodes between S and D. Node X detects route breakage in Figure 3 and it broadcasts a HELP message in Figure 4 and node p replies it and Z in Figure 5, and the broken route is locally reconstructed using QLRS-APM which is depicted in Figure 6.

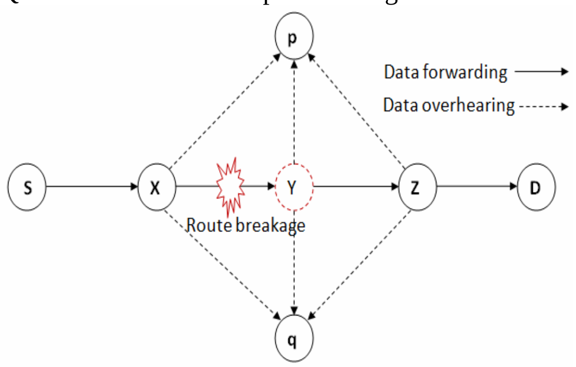

Fig. 3. Detection of route error by X

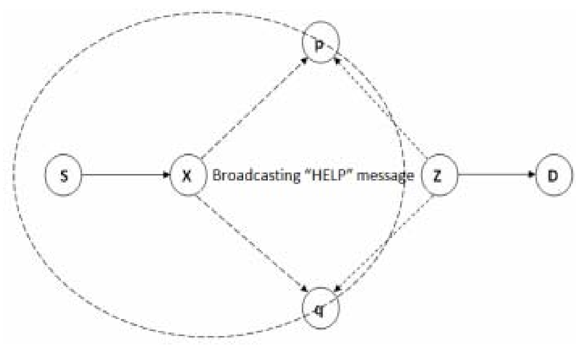

Fig. 4. Broadcasting help message by X

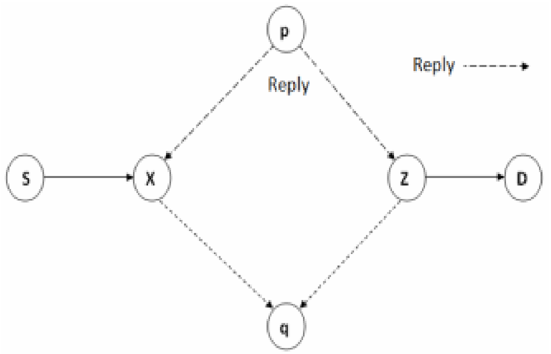

Fig. 5. Reply to HELP message.

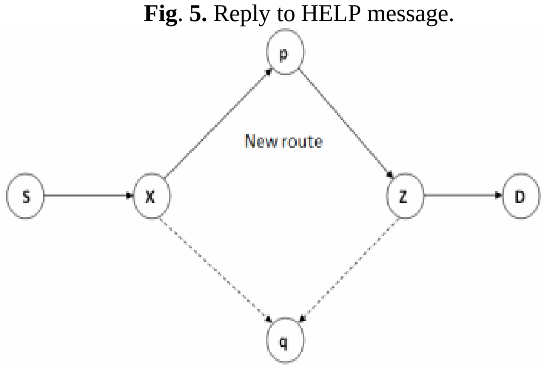

Fig. 6. Route is recovered using QLRS-APM

III. Motivation

QLRS-APM tries to repair route error locally. Suppose a node put into in promiscuous mode for three adjacent nodes on an ongoing route. This scheme can repair the route breakage immediately for the first link error but generates a route error to the source node for the last link fails. Specially, for each overhearing node besides the ongoing route, QLRS-APM cannot repair the last link caused by the mobility of the last node among the three nodes even if the last node is overheard by at least one overhearing node. This type of route error is being observed and handled in this proposal by providing a solution related to that route error generated in QLRS-APM. In the next section, proposed extension on QLRS-APM is explained including all the necessary steps for successfully repairing the last link.

IV. Proposed Modified QLRS-APM Technique

In Figure 7, nodes p and q maintain promiscuous mode for three adjacent nodes X, Y and Z on an ongoing route. QLRS-APM correctly rebuilds the route from the source to the destination for the link error between nodes X and Y. But, for the link error between Y and Z caused by the mobility of node Z, QLRS-APM always initiates a route error message to the source. The main goal of this paper is to minimize the route error message to the source as less as possible by not initiating route error message to source for the link error between the nodes Y and Z and giving a way to repair this route breakage locally. This proposal on QLRS-APM can repair this route breakage between Y and Z in case of mobility of Z and if Z is still overheard by any node in promiscuous mode which is illustrated next by showing a network scenario.

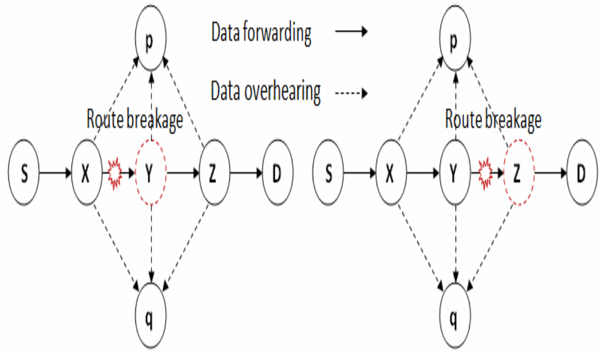

Fig. 7. Two different route breakages

A. Modified QLRS steps for the observed link error

Step 1: Route error detection

Suppose a node S is communicating with a node D by using the route S-X-Y-Z-D and a route error occurs between Y and Z in Figure 8. Any link disconnection is detected by not receiving any ACK messages after sending data or not receiving clear to send (CTS) messages after sending request to send (RTS) messages.

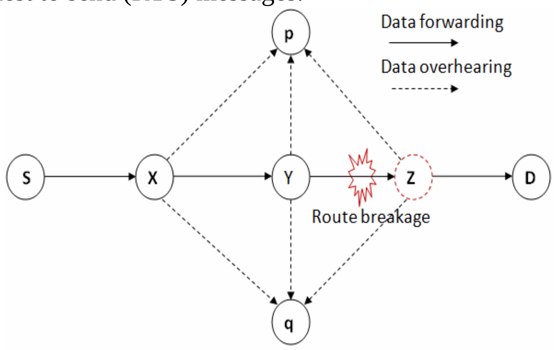

Fig. 8. Route error detection

Step 2: Broadcasting HELP message

After detecting a link error with Z, Y broadcasts a HELP message for any node in promiscuous mode which is shown in Figure 9.

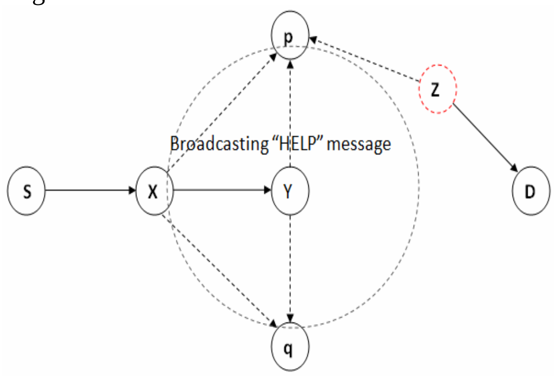

Fig. 9. Broadcasting HELP message by node Y

Step 3: No approval message received by the error detecting node

Error detecting node will not receive any approval message from any overhearing nodes. There exists no overhearing node which knows the latter of error node. Thus, Node Y will not receive any reply in Figure 10.

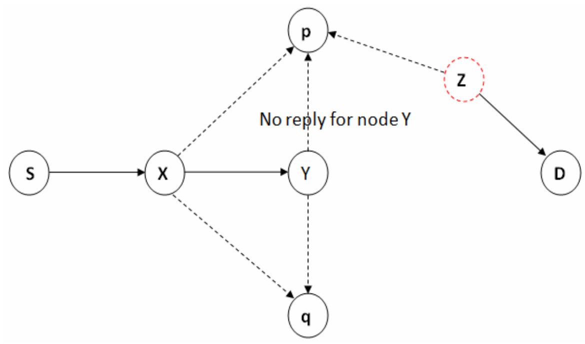

Fig. 10. No approval message received by Y

Step 4: Generate route error to immediate former node

Error detecting node sends a route error message one hop backward to the immediate former by setting the TTL=1. So, a route error is generated containing the link error information and it is sent backward to the immediate former on this route. In Figure 11, node Y sends route error message to immediate former node X

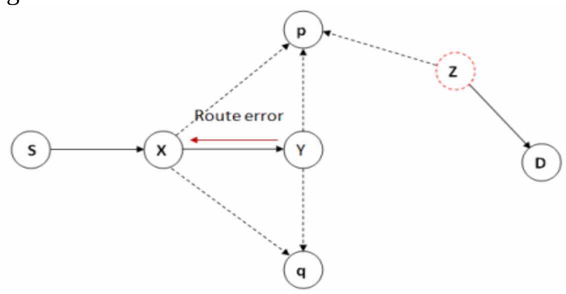

Fig. 11. Route error to former node

Step 5: Sending HELP message by former node

When the error message has arrived at the immediate former of the error detecting node, then this node grabs the message and tries to repair the route locally. It then broadcasts again HELP message and waits for reply messages as answer to the HELP message. In this case node X broadcasts a HELP message in Figure 12.

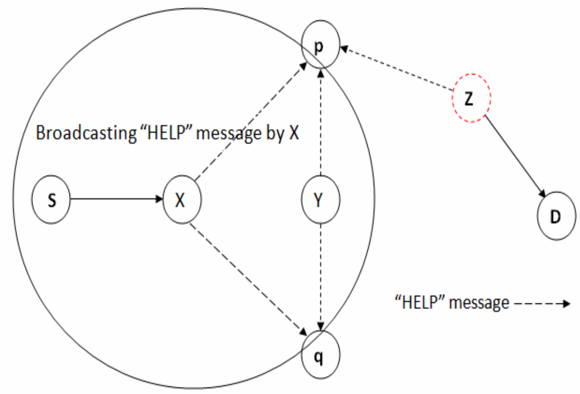

Fig. 12. Broadcasting HELP message by X

Step 6: Determining the possibility of quick local repair

Each node maintaining promiscuous mode examines its routing table and tries to send approval to the former and last of the three nodes. An overhearing node will reply if the error node is observed by it in that period of time. In case of more than one approval messages arrived at the former node, the first approval message will be selected always as it is done in QLRS-APM. Node p sends an approval message to node X and node Z in Figure 13.

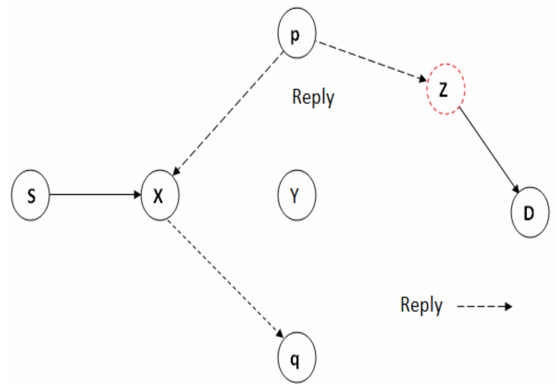

Fig. 13. p approvals to X

Step 7: Completing quick local repair

After receiving the approval message from any overhearing node, former and error node change their routing table. After that, the local route repair process is over and a new route S-X-p-Z-D is reconstructed locally using modified QLRS-APM in Figure 14. If former node of error detecting node does not receive any approval message, it then sends a route error message to the source node otherwise not.

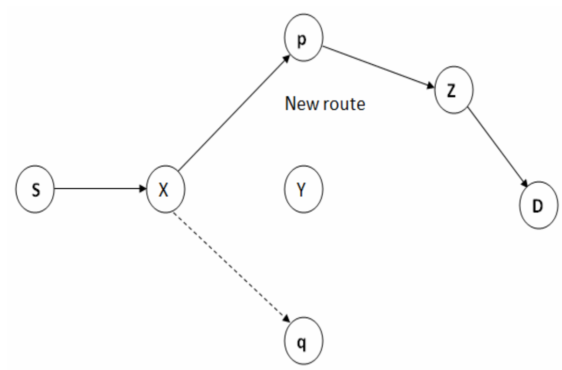

Fig. 14. Locally reconstructed route

B. Steps performed by any routing node

The tasks such as transmitting packets, determining link disconnection, sending HELP message, receiving reply message, changing routing table performed by a routing node in modified QLRS-APM are illustrated as flowchart in Figure 15.

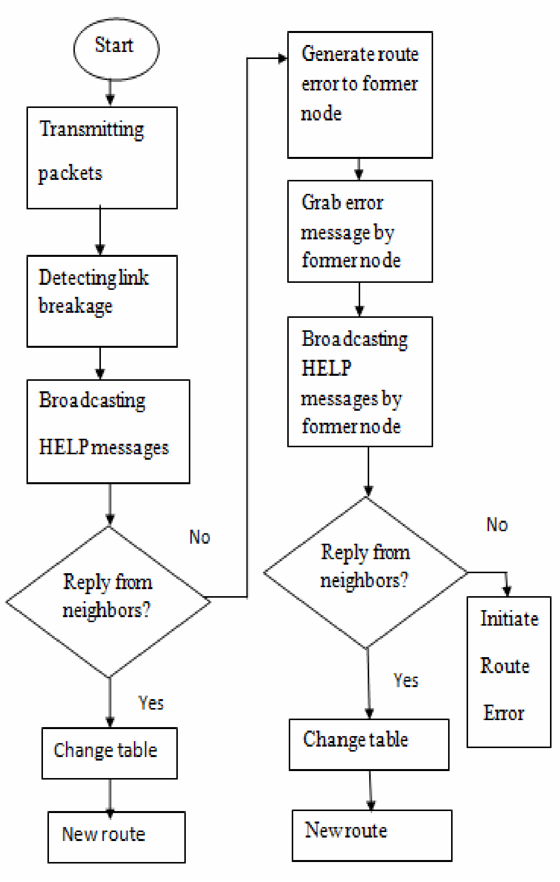

Fig. 15. Tasks performed by a routing node

V. Performance Evaluation

For simulating proposed modification on QLRS-APM, several network scenarios are considered and the proposal is implemented on these networks. Finally, found the results that more route error can be repaired locally by using the modified QLRS-APM than QLRS-APM. One network scenarios is given here which is depicted in Figure 16. When communication is performed between the source and destination node, many possible route errors may occur in this network. These route errors are trying to repair locally using the QLRS-APM only and then also by the modified QLRS-APM separately.

Table. 1. Results from the network in Fig. 16.

Route error	QLRS-APM	Modified QLRS-APM
Link error (1,2)	Yes	Yes
Link error (2,3)	Yes	Yes
Link error (5,6)	Yes	Yes
Link error (6,7)	Yes	Yes
Link error (3,4)	No	Yes, if overhearing node 10 overhears packets from node 4
Link error (7,8)	No	Yes, if overhearing node 12 overhears packets from node 8
Power down of node 4	No	No

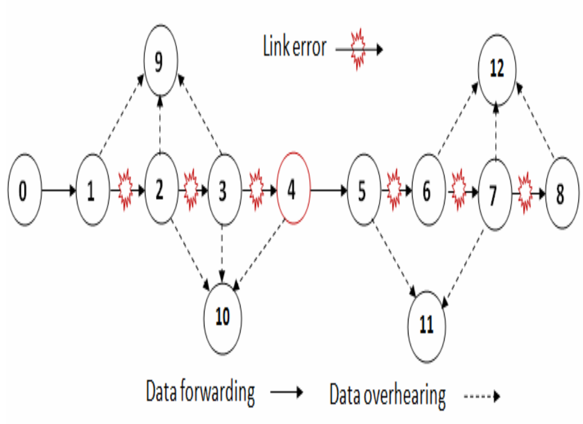

Fig. 16. Network with possible route errors

The results obtained from the simulation of network scenario specified in Figure 16 are shown in the form of a Table 1. A `Yes' value in this table indicates that the corresponding approach can repair the broken link locally. On the other hand, a `No' value indicates that the corresponding approach cannot repair the link breakage locally. From this table, it is easier to claim that the proposed modified QLRS-APM performs better than QLRS-APM in case of repairing route error locally.

A comparative analysis of these two approaches namely QLRS-APM and modified QLRS-APM is also done in Table 2 for the network in Figure 17. Link breakage between node X and node Y can be repaired by QLRS-APM and also by using the proposal. Link breakage between the node Y and node Z cannot be repaired by using only QLRS-APM but can be repaired by using the modified QLRS-APM if the node Z is overheard by any overhearing node at that time period when route error occurs. The route error will be repaired from the overheard information of Z's transmission by any overhearing node. In case of power failure of node Z, there is no chance to repair broken route. Since, al the overhearing nodes of these three nodes do not know the latter of this error node.

Table. 2. Summarizing results from Fig. 17.

Route error	QLRS-APM	Modified QLRS-APM
Route error #1	Yes	Yes
Route error #2	No	Yes, if overhearing node overhears node Z.

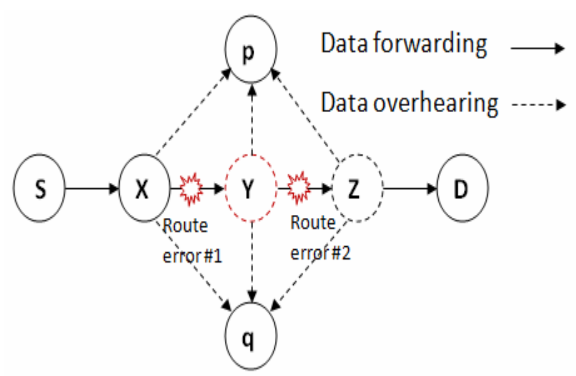

Fig. 17. Two different route errors

VI. Conclusion

QLRS-APM and its extension will be best to use if the position of route error occurrence is closer to the destination than source. Suppose a route is twenty hops distant from source to destination and route error is occurred at 18th hop. Without local route repairing in this situation, simple route maintenance draws unwanted scarce energy from the network. There are cases that cannot be repaired by both approaches which are when there are no available non routing nodes in promiscuous mode in the error zone or also for sudden power down of last mobile node among the three consecutive nodes on any route. Although, this research not proposing any complete model in local route repairing, but it improves the performance of networks by not initiating one type of route error to the source. It helps the source node to become less burdened and ultimately less energy will be consumed from the network. This is the achievement of this modified QLRS-APM. The new proposal on QLRS-APM also allows a node automatically performs the operation of promiscuous mode only when nodes are able to participate in the repair of a broken link in their local domain. Thus, there is no extra overhead needed for maintaining the promiscuous mode in this research over QLRS-APM. In this case, one active node is discarded from the original route. The number of hops in this new route after local repair is still remaining the same as the original route.

References

1. Jayakumar, G. and G. Gopinath, 2007. Ad Hoc Mobile Wireless Networks Routing Protocols–A Review. *Journal of Computer Science,* **3(8)**, 574-582.
2. Jain, J., M. Fatima, R. Gupta, and K. Bandhopadhyay, 2009. Overview and Challenges of Routing Protocol and MAC Layer in Mobile Ad-Hoc Network. *Journal of Theoretical and Applied Information Technology*, 6-12.
3. Johnson, D. B., and D. A. Maltz, 1996. Dynamic source routing in ad hoc wireless networks. *Kluwer International Series in Engineering and Computer Science*, 153-179.
4. Perkins C. E. and E. M. Royer, 1999. Ad-hoc On-Demand Distance Vector Routing. *Proc. of 2nd IEEE Workshop on Mobile Computing System and Applications.* 90-100.
5. Perkins C. E. and P. Bhagwat, 1994. Highly Dynamic Destination Sequenced Distance-Vector Routing (DSDV) for Mobile Computers. *Proc. ACM SIGCOMM Symp, Comm., Architectures, and Protocols.*
6. Duggirala, R, R. Gupta, Q.A. Zeng and D.P. Agrawal, 2003. Performance Enhancements of Ad Hoc Networks with Localized Route Repair. *IEEE Transactions on Computers,* **52 (7)**, 854–861.
7. Lee, S. J. and M. Gerla, 2000. AODV-BR: Backup Routing in Ad hoc Networks. *Proc. of IEEE Wireless Communications and Networking Conference (WCNC),* **3**, 1311–1316.
8. Aron I. D. and S. Gupta, 1999. A Witness-Aided Routing Protocol for Mobile Ad-Hoc Networks with Unidirectional Links. *Proc. of International Conference on Mobile Data Access*, 24–33.
9. Youn, J. S., J. H. Lee, D. H. Sung and C. H. Kang, 2006. Quick Local Repair Scheme using Adaptive Promiscuous Mode in Mobile Ad Hoc Networks. *Journal of Networks,* **1(1)**, 1-11.