Applied Mathematics & Information Sciences
An International Journal

http://dx.doi.org/10.18576/amis/110614

Reliable Energy based Efficient Protocol for Improving Fault tolerance in Mobile ad hoc networks

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Received: 11 Jul. 2017, Revised: 12 Oct. 2017, Accepted: 16 Oct. 2017
Published online: 1 Nov. 2017

Abstract: In Mobile Ad-Hoc Network all mobile nodes are communicated in the absence of access point. The previous fault tolerant routing in ad hoc network does not focus on real time issues in packet forwarding. Due to mobility of mobile node causes the frequent link changes, path may break frequently which leads to network degradation. To solve the path failure and packet dropping, a new protocol called Fuzzy logic based Reliable Stability enhanced Fault Routing Protocol (FRSFRP) is proposed to improve the network performance. In this protocol, there are three phases. In first phase, load balanced routing is established from source to destination. There is need to select the reliable nodes during packet forwarding. In second phase, Cluster head is the responsible node to select reliable nodes based on the calculation of node reliability. In last phase, packets are forwarded to destination node through the reliable nodes. In the presence of mobile environment, the proposed protocol FRSFRP achieved better performance in terms of packet delivery rate, forwarding rate, overhead, delay and network lifetime based on network simulation tool (NS-2) than the existing protocols i.e. LAER, ARCCRP, RFTA and CDN.

Keywords: MANET, Load balanced Routing, overhead, delay and network lifetime

1 Introduction

Mobile ad hoc networks (MANET) consist of mobile nodes in the absence of infrastructure. The network has been deployed in all emergency and rescue operations i.e. manmade disasters, rescue activities, battle fields or seminar halls significantly in areas. All nodes are communicated within the transmission range and associated with some degree having packet forwarding knowledge between source and destination node.

There are three major categories of ad hoc routing protocols.

1 In proactive routing protocol, each and every node has full path information stored in their routing table to destination node.
2 In reactive routing, it initiates route establishment when it has data packets to forward.
3 In hybrid routing, the routing structure is the combination of proactive and reactive approach to overcome the issues of each protocols.

In ad hoc networks, transmission links are susceptible and receptive to channel characteristics. Links are broken due to high mobility of nodes. It leads to degradation in the network performance. To have reliable routes and nodes, there is a need to links with more reliability metric. In [1], authors reviewed MANET and have shown the performance of energy aware routing protocols based on power, and link failure. Compared to proactive routing protocol, on demand routing protocols consumes more power and less probability of node failures. The major issue is that heavy packet loss due to dynamic link routing. It leads to more consumption of energy. In proactive routing, there is less route breakage but time delay is more compared to reactive routing.

2 Related work

Ajay Shah et.al [2] proposed a energy efficient routing protocol without redundant rebroadcasting of RREQ packets. To reduce the redundant rebroadcasting, the energy of all mobile nodes is saved. The route request packets decides the relaying status through neighbor nodes. The overhead was reduced during route discovery process.

Jayad Vazifehdan et.al [3] introduced two energy aware routing algorithms i.e. reliable minimum energy

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cost routing (RMECR) and reliable minimum energy routing (RMER). Both routing schemes address the major issues in ad hoc networks i.e. network lifetime, energy efficiency, reliability and path stability. It was also considered that energy consumption, residual battery energy and link quality in order to find energy-efficient and reliable routes that increase the operational lifetime of the network. The total energy required for end to end data packets traversal is reduced with the help of reliable minimum energy routing.

Santhosh et.al [4] proposed the reliable protocol based on energy consumption to improve the Quality of Service (QoS) based on network stability, and network lifetime. The reliable backbone nodes are formed and it was incorporated in existing routing protocol i.e. Ad hoc On Demand Distance Vector (AODV) protocol. Stable routes are established and battery power and signal strength were measured perfectly to achieve QoS.

Sudhir Goswami et.al [5] developed reliable energy efficient protocol based on AODV. The routing capability of AODV is improved with the help of energy dependent nodes. In the network, mobile nodes are not aware of energy status and more packet flooding leads to high energy consumption. In connection establishment phase, energy may be wasted which leads to network degradation. By maintaining the accurate position of mobile nodes, the possibility of destination finding will be greatly reduced.

Vadivel and Murali Bhaskaran [6] proposed the energy efficient with secured reliable routing protocol towards mobile ad hoc networks. To provide reliability and energy efficiency, a residual energy metric was estimated. An efficient intruder detection and correction was introduced to protect nodes from malicious attackers. The residual energy estimation and traffic inspection was obtained to achieve more reliability. This traffic inspection was carried out based on packet loss rate through neighbor nodes. Packet loss rate was accurately measured.

Rajeshkanna et.al [7] introduced the modification of AODV protocol with more energy efficiency. The network survivability increases battery life to balance energy consumption with minimum overhead. It was concluded that there is not a single protocol which can give the best performance in ad hoc network. According to the variation in the network parameters, the protocol performance may be varied.

Saravanan Nallusamy et.al [8] proposed Mobile Agent based Energy Efficient Reliable routing protocol for ad hoc networks. The reliability of network is measured based on cost metric, node burthen degree and bandwidth usable degree Minimum Drain Rate (MDR) and Link availability. All the mobile agents are organized and transferred in a hop by hop manner until the destination is reached. The information about the transferred based on link cost metric.

Markand et.al [9] proposed a new energy efficient scheme in the routing protocol for mobile ad hoc network which will efficiently utilize the battery power of the mobile nodes energy consumption and increases the lifetime of the network. The on demand routing protocol uses only the shortest path between source to destination in the absence of intermediate node energy. The proposed algorithm not only considers energy of the node while selecting the route but also takes into account the number of packets buffered in the node.

Ramanna Havinal [10] introduced a novel topological based approach which consists of novel mechanism of energy aware routing protocol. The concept of availability zone was deployed and positional information was passed throughout the neighbor nodes. The query message was sent by source node to perform routing. The availability of destination nodes will be checked within zones to ensure energy conservation with effective routing.

Kirandeep Kaur and Sheetal Kalra [11] proposed energy efficient routing algorithm based on route request process. The energy levels and location of destination node will be proposed through the proposed routing scheme. To make intelligent route request forwarding, destination's node location was obtained. The location of neighbor nodes is compared with the broadcasting. If any neighbour node is lying in the quadrant that is towards the destination node only then it will be considered for forwarding the packets.

Mahfuzur et.al [12] developed Energy-Aware and Error Resilient (EAER) routing protocol for MANETs. The routes were constructed through intermediate nodes with minimum of packet forwarding capability. The routing metric combines remaining energy and successful packet transfer capability. If the node's current energy level is below threshold level, the lifetime of node is reduced.

Rango et.al [13] proposed the link and energy aware routing in distributed ad hoc networks. Authors were not focused on stability metric to increase the energy efficiency of the network.

Khaitiyakun [14] introduced the data dissemination approach in Content Delivery Network (CDN). Here the data packet is delivered via the nodes which are closer to final destination than the original sender node. Multipoint relays are used to cover the subscriber nodes based on optimized link state routing.

Vadivel and Murali Baskaran [15] proposed the concept of adaptive reliable and congestion control routing protocol to control congestion and reduce transmission errors. The congestion was detected according to the utilization and capacity of link and paths

Vinothkumar et.al [16] developed the Multipath Fault Tolerant Routing Protocol to improve the reliability of data routing in MANET. It is a multi objective routing protocol based on the considerations network changes scenarios and requirements of application layer.

The paper is organized as follows. Section 1 describes the fundamentals of mobile ad hoc networks, and contribution of this analysis work. Section 2 presents the literature survey associated with reliable routing in ad hoc approaches. Section 3 is devoted for the implementation of proposed protocol. Section 4 describes the performance analysis and also the final section concludes the work.

3 Overview of frsfrp protocol

The proposed protocol FRSFRP contains three phases i.e. load balanced routing, reliable node selection through fuzzy model, and packet forwarding phase. In load balanced routing, nodes are randomly sending and receiving the packets. Routes are discovered based on

3.1 Load balanced routing

In load balanced routing, there are two stages. i.e. Route discovery and Route maintenance stage. The route is constructed based on the following steps.

Step 1:Estimation of remaining energy using energy model.
Step 2:Computation of reliability metric
Step 3:Removing the mobile nodes which is having remaining energy less than threshold value. Here the estimated threshold energy value is 85 Joules.
Step 4:Establishing multiple routes to the destination node.
Step 5:Selection of stable routes among multiple routes based on the estimation of remaining energy of mobile nodes and reliability metric of mobile nodes.
Step 6:Broadcast reliable and stable route information to all mobile nodes.
Step 7:Form the cluster region and cluster head stores the information about all stable routes and reliable nodes.

3.1.1 Route discovery phase

In route discovery stage, there are two phases involved i.e. route request phase and route reply phase.

In route request phase, Cluster Head (CH) initiates the route discovery mechanism by sending Route Request (RREQ) messages to all mobile nodes inside the network transmission region. All neighbour nodes remove all routes to CH before processing the starting RREQ messages. Including this, each neighbour node stores the reverse route information based on first received RREQ messages. It is required to ensure the fresh routes to be used in route reply phase. The timer will be generated after receiving the first RREQ message and establish the primary path.

In route reply phase, route reply (RREP) packets are generated at multiple destinations and it is directed to CH through the path and stored in visiting route information table. At every crossed node, routing information is updated by the RREP packets for destined cluster head. All visited node removes the temporary information for every corresponding RREP packets.

3.1.2 Route maintenance phase

In order to balance the issues in link failure, node failures, and loss of reliability metric, it is required to construct reliable path from cluster head to cluster members or destined cluster head. Cluster head consists of neighbour nodes in the primary path. The destination CH is used in checking the availability of alternative paths. In case of link breaks between neighbour nodes, the node detecting failure issues will utilize the RREQ and RREP packets to find the stable path. The new route may be generated if an existing route failures. Cluster head stores the backup path if it is working and uses this path for route failure conditions.

If node failure occurs in case of power failure, node may get overloaded due to heavy traffic and it may be hijacked by malicious activities. If node recovers from failure, it notifies its reappearance to neighbour nodes using hello messages by advertising to become a part of routing function.

If some loss of reliability metric occurs, it leads to network degradation. It happens because of high speed node, transmitting data at higher rate, low batter power level and malicious behaviours. A fresh path should be setup using reliable nodes.

3.2 Reliable Node selection though Fuzzy model

Reliable node is chosen based on received signal strength calculation, link stability procedure and the estimation of reliable metric.

3.2.1 Calculation of Received Signal Strength

There are some assumptions made here to estimate received signal strength.

1.Strength of signal is measured at a destination node.
2.Minimum power level is required to every mobile node.
3.Differential Signal strength (DS) may be differed from node to node. If the mobile nodes are moving in same direction, DS will be positive otherwise negative.
4.To provide the successful delivery of packets at the destination, a minimum threshold power level should be maintained.
5.If the received power level is below the threshold value, a high bit error will be generated and it leads to transmission error.
6.If a mobile node goes out of the transmission range, the last received power level may be estimated to reported to cluster head.
7.The differential signal strength is calculated as,

$$DSS^{a}_{(b,t)} = RSS_{(b,0)} - RSS_{(b,t)} \quad (1)$$

$$DSS^{b}_{(a,t)} = RSS_{(a,0)} - RSS_{(a,t)} \quad (2)$$

where $RSS(b,0)$ and $RSS(b,t)$ are the received signal strengths of node b received at node a with minimum power level.

8. The link stability is computed based on signal strength values from the medium access layer. Any link with link stability is given by,

$$RL_{ab} = \frac{v_2 - SS_{ab}}{v_2 - v_1} \tag{3}$$

SS is that the signal strength with different values based on node velocity. v_1, v_2 square measure the velocity of the bidirectional links. It decides whether or not the signals are becoming stronger or weaker.

9. Reliability metric is computed based on estimated power level, node mobility, link stability and received signal strength value. The estimated reliable metric as follows,

$$RM = U \frac{RL_{ab} \min\left\{E_a^{rem}, E_b^{rem}\right\} + \left\{DSS^a_{(b,t)}\right\}}{d(ab,0)} \tag{4}$$

$$RM = U \frac{RL_{ab} \min\left\{E_a^{rem}, E_b^{rem}\right\} + \left\{DSS^a_{(b,t)}\right\}}{d(ab,t)} \tag{5}$$

where U is a proportional constant, RL_{ab} is the estimated link stability between node a and b, E_b^{rem} is remaining energy of either node a or b. DSS is the differential signal strength and d is the distance between cluster head to cluster members at different velocity in free space propagation model at time t.

10. Choose the node with high reliability metric. The transmission region will be expanded according to node mobility.

11. Choose the mamdani fuzzy model [**?**] to select reliable node based on link stability and reliability metric.

3.3 Packet forwarding phase

In this phase, packets are forwarded through reliable nodes. CH will initiate the forwarding phase after the establishment of reliable routes. Routes are found with link stability, high signal strength and reliability metric. The phase is started as

Step 1: Update the location of reliable nodes through reliable routes.

Step 2: Cluster head stores the location of reliable nodes and broadcast the information to cluster members.

Step 3: Forward the packets to the destination through reliable routes to increase the delivery rate. The probability of packet loss rate is reduced through reliable metric.

Table 1: Simulation settings and parameters of FRSFRP.

No. of Nodes	150
Area Size	1100×1100 m^2
Mac	802.15.4
Radio Range	250m
Simulation Time	100 sec
Traffic Source	Constant Bit Rate (CBR)
Packet Size	512 bytes
Mobility Model	Random Walk
Output Power	0.0789 watts
Protocol	DSR
Antenna	Omni directional
Propagation model	Free Space propagation model

4 Performance evaluation

4.1 Simulation Model and Parameters

The projected protocol is enforced with the article bound distinct event machine. In our simulation, 150 mobile nodes move during 1100×1100 m^2 region for 100 seconds simulation time. We have a tendency to assume every node moves severally with identical average speed. All nodes have identical transmission vary of 250 meters. The simulated traffic is Constant Bit Rate (CBR).

Our simulation settings and parameters are summarized in Table 1

4.2 Performance Metrics

We evaluate mainly the performance according to the following metrics.

Data packet delivery ratio: The information packet delivery magnitude relation is that the ratio of the amount of packets generated at the sources to the amount of packets received by the destinations.

End-to-end delay: This metric includes not solely the delays of knowledge propagation and transfer, however conjointly all attainable delays caused by buffering, queuing, and retransmitting information packets.

Network lifetime: It is outlined by the full energy consumption divided by the full variety of packets received. This metric reflects the energy potency for every protocol.

Fault tolerant rate: It means that number of links which is tolerable to environment changes. It should be high.

Overhead: It is the number of excessive control packets and it is normalized to total number of control packets.

4.3 Results

Fig. 1 shows the packet delivery ratio with increasing quality. As quality will increase, the wireless link

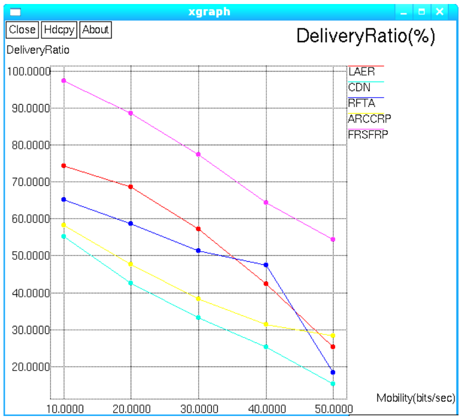

Fig. 1: Mobility Vs delivery ratio.

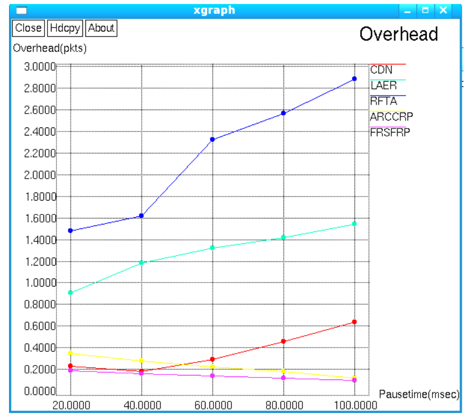

Fig. 2: Pause time vs. Overhead.

conjointly gets increasing. This can result in network partition. Compared to the previous schemes LAER, RFTA, ARCCRP and CDN protocol, FRSFRP shows best performance in packet delivery ratio. Both are integrated in the routing to stabilize the network performance. The probability of reliable links is maximum in the proposed protocol compared to the previous schemes. Connectivity of the link is maximum in the proposed routing. While increasing the mobility, the connectivity ratio of proposed algorithm is higher than the existing schemes

Fig. 2, presents the comparison of overhead and pause time. Once pause time will increase, communication is suppressed between the supply and destination. It is clearly shown that the overhead of FRSFRP achieved 0.18–0.07 packets than LAER, RFTA, ARCCRP and CDN protocol. When we increase the time, the mobility is also getting increasing. Mobility of nodes will lead to network partition. In our proposed model, mobility is kept less dynamic. Nodes transmit the packet towards the destination with less delay. Packets propagating delay and transmission delay are kept low. The proposed protocol has low end to end delay per packet than the existing routing schemes.

Fig. 3 shows the results of Network Lifetime while varying number of nodes. From the results, we can see that FRSFRP scheme has higher Network Lifetime (228–678) seconds than LAER, RFTA, ARCCRP and CDN protocol while varying the number of mobile nodes from 10 to 50. The unwanted node communication is reduced which increases the whole network lifetime in the proposed scheme. While increasing the speed, packets are moving randomly with variable transmission rate towards destination. In our proposed model, we schedule the packets through link. Accordingly, packets are arrived at the destination. The problem of congestion overflow and packet dropping is decreased. So the proposed scheme achieves less control overhead instantaneously.

Fig. 4, presents the comparison of End to end delay varying the Speed from 20 to 100 secs. It is shown that

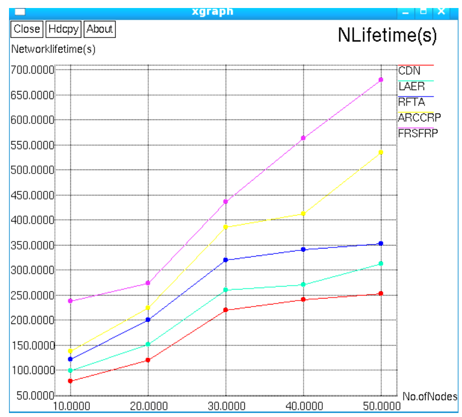

Fig. 3: No.of nodes vs. Network Lifetime.

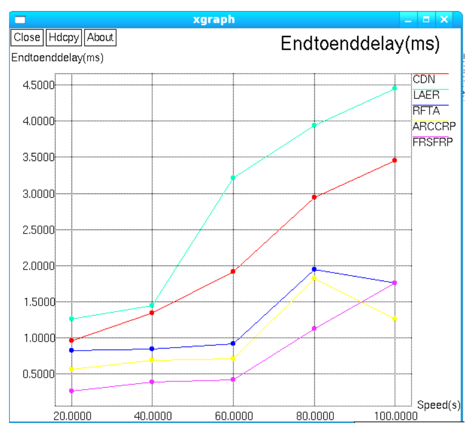

Fig. 4: Speed vs. End to End Delay.

the delay of FRSFRP achieves 0.3–1.7 seconds than the LAER, RFTA,ARCCRP and CDN protocol. Delay of proposed scheme is decreased because of keeping genuine packets in the path and making pause time

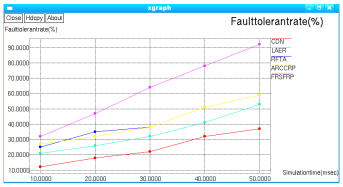

Fig. 5: Simulation time vs. Fault tolerant rate.

between the packets low. This is also referred to as latency and is the time needed to deliver the message. Data delay can be divided into queuing delay and propagation delay. If queuing delay is ignored, propagation delay can be replaced by hop count, because of proportionality.

Fig. 5, presents the comparison of fault tolerant rate while varying the Simulation time from 10 to 50 ms. It is clearly shown that the fault tolerant rate of FRSFRP achieves 38–97 ratio than the LAER, RFTA, ARCCRP and CDN protocol. When it is combined both fault tolerant routing and reliable node selection, fault tolerant rate is automatically increased. Our proposed protocol FRSFRP achieves 97% rate than previous schemes.

5 Conclusion

The research work has focused on reliable node selection based on mamdani fuzzy model which is focused to ensure the reliable network. In the first phase, the load balanced routing is initiated to ensure maximum packet delivery. In second phase, the reliable nodes are chosen based on reliability metric, link stability and fuzzy decision mechanism. In last phase, the packet forwarding is initiated to reduce packet loss rate. By exploitation the in depth simulation results, the planned theme FRSFRP achieves the higher packet delivery magnitude relation, fault tolerant rate, network life low delay and overhead than the present schemes like CDN, ARCCRP, RFTA and LAER whereas variable the quality, time, simulation time, pause time and speed.

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