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RERMRS: Residual Energy based Reliable Multipath Routing Scheme for increasing Network Lifetime in MANET

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Abstract

Reliable route selection is a major issue in Mobile Ad hoc Networks (MANETs). To establish route with more reliability, there is a need of stability and link tolerability. In previous works, it was identified that only stability is adopted for route reliability selection. In this research work, Residual Energy based Reliable Multipath Routing Scheme (RERMRS) to increase network lifetime based on fault tolerable routes. These routes are established as multiple routes by selecting path reliability parameters and expected transmission period metric. In first phase, multipath route establishment is implemented with reliability count value and minimum route error messages. In second phase, the fault tolerable routes are identified in either primary routes or alternative routes based on the calculation of tolerability rate. In last phase, energy consumption after route transmission and reception is implemented to achieve maximum energy efficiency. From the simulation results, the proposed scheme achieves better results in terms of energy efficiency, remaining energy, fault tolerability rate, end to end delay and overhead than previous schemes.

Keywords: MANET, multipath, path reliability, fault tolerant, remaining energy and delay etc.

INTRODUCTION

Mobile ad hoc network (MANET) is a special category of ad hoc network where the mobile nodes are randomly moving inside and outside the network region. In the absence of network infrastructure, nodes are vulnerable to attackers and links may be often broken and it may not be suitable for real life scenarios. In starting phase, MANET was widely used in military applications, disaster and earthquake applications. Reliability is a major impact on all paths from source to destination nodes. In [1] Fault tolerant QoS Routing Protocol (FTQRP) was adopted to attain high tolerant route in the presence of mobile environment. Alternate routes are discovered if the route breaks occurs. Packets are sent through alternative routes to achieve more packet delivery ratio. Mobile nodes are randomly moving inside and outside the network. In previous work of this protocol, genetic algorithm was implemented to address routing with the help of network redundancies. In this QoS protocol, more fault tolerant rate has been improved than genetic algorithm. In the proposed scheme, multiple routes are discovered and identified with tolerability rates. Optimum energy efficient model was adopted to increase the remaining energy of the network.

The paper is organized as follows. Chapter 1 introduces the MANET and reliable routing. Chapter 2 discusses the recent reliable routing protocols, algorithms and schemes etc. Chapter 3 introduces the proposed scheme. Chapter 4 conveys performance results of proposed and existing schemes. Last chapter concludes the work and future work.

RELATED WORK

Kulwinder Kaur and Kamaljit Kaur [2] have reviewed and presented different fault tolerant routing algorithms and protocols for ad hoc wireless networks. Various handling problems like node failures, link failures, and transmission power and energy dissipation were analyzed and solutions were given to those issues. The overall performance based on throughput, reliability and network lifetime was recorded in the presence of fault tolerant routing schemes.

Zeeshan Iqbal et.al [3] proposed an adaptive and cross-layer multipath routing protocol for changing mobility scenarios. This protocol was inspired from traditional on demand protocols while searching paths from source to destination nodes with QoS network parameters. The proposed mechanism consists of fault tolerable routes having high data rates with less packet loss ratio. These routes are adaptive with more data rate and high integrity. Two or more fault tolerable routes were taken for multimedia and sensitive applications.

Senthil et.al [4] introduced energy efficient QoS routing to estimate parameters of link reliability with the help of fuzzy logic technique. While adopting this approach, routing layer will be more robust. From the OSI architecture, link layer, routing and physical layer performs better. The Signal to Interference plus noise ratio can be calculated using physical layer. The neighbor status and back off time can be estimated for link layer. Data rate and data count information were calculated to decide the packet transmission status.

Nisha Chaudhary et.al [5] have made an analysis on fault tolerant methodologies to route packets along the optimized paths. All the paths have threshold signal strength to achieve more energy efficiency. Route discovery and route maintenance are continuously monitored to avoid packet loss in the presence of link mobility.

Fatemeh Tavakoli et.al [6] proposed efficient fault-tolerant routing algorithm for MANET. Network fault tolerance and natural redundancy was successfully improved using this algorithm. Initially, selection f backup routes and nodes were chosen by predicting reputation parameters. Fault tolerant routing will be initiated once the selection of backup of nodes was over. The primary route between pair of source and destination was estimated.

Saravanan Nallusamy et.al [7] introduced the new reliable protocol called Mobile Agent based Energy Efficient Reliable routing protocol to improve the link cost metrics i.e network load and link availability. All the mobile agents are randomly deployed and packets are transferred in a hop by hop manner once it reaches the destination. From this traversal, node agents can collect the combine link cost metrics and source agents may able to select the optimal path.

Monisha rani and Amit [8] have introduced the new concept of link optimization procedure to extract the bandwidth efficiency using window channel. It was considered that previous obstacles and solutions were found to improve the energy efficiency. The optimal network path was established from source to destination by considering link cost metrics and node trust parameters.

Suhail and Nidhi [9] explored Interference aware and Fault tolerant Multipath Routing protocols in the presence of mobile environment. The major metrics which could affect the routing protocols are mobility, limited bandwidth and power. The main focus on this work is to increase the packet delivery ratio by distributing network traffic load. The interference impacts were successfully reduced in between the node disjoint routes.

Rakesh Meena et.al [10] proposed the topology transparent routing to achieve the improvement in network performance. There are three different network scenarios adopted to attain more gain. Network was kept as static and dynamic. Energy estimation was done in the last scenario. Routing steps were modified according to the energy level of mobile nodes. The concept of shortest path mechanism was established to achieve high energy efficiency.

Soon gyo Jung et.al [11] presented an energy efficient routing protocol based on ant behavior. The problem of additional traffic was solved with the help of ant behviours. The concept of forwarding nodes and the routing trail were adopted in stochastic manner. Based on Ant Colony Optimization (ACO) technique, the additional traffic was reduced.

Baolin Sun et.al [12] developed a new multipath algorithm called Energy Entropy-based minimum Power cost Multipath routing algorithm (EEPMM) to improve reliable transmission and to achieve load balancing of packets. The network lifetime was maximized by reducing the total transmission power. The link power has been improved while selecting optimized network parameters.

Sugandh and Panday [13] introduced the energy efficient LEACH protocol for prolonging lifetime of nodes and paths. Cluster head is chosen based on high energy efficiency and low packet loss rate. Cluster head maintains all cluster members and updating cluster member tables, This table includes previous routing history, energy consumption status, and network load. The main drawback of this work is more overhead.

Kokilamani and Karthikeyan [14] proposed Geographical Distance based Ad Hoc On-demand Distance Vector Routing (GD-AOMDV) to select optimal route with least hop distance. The connection between path distance and parameters of MANET based on bandwidth, energy consumption and transmission range. Multiple paths are chosen based on least hop distance. Route Request (RREQ) packets collect all the information about paths and neighbor nodes and send it to source node. The network parameters link end to end delay, congestion rate and large queue of packets were reduced.

Narayanan et.al [15] presented fault tolerant routing for selecting cluster head with maximum energy efficiency. The link failure was mitigated by deploying local repair method. This method was utilized for avoiding link breakages. However, this routing suffered from excessive routing overhead and more delay.

Nandhini and Sharmila [18] developed an effective and secured message broadcasting model to achieve better results over authentication with least energy consumption. The secure broadcast model was used to minimize overhead based on the evaluation of confidentiality and authentication through source node. The confidence correlation measure was calculated to find the authenticated route between source and neighbor nodes.

IMPLEMENTATION OF PROPOSED SCHEME

In this research work, multipath establishment has been implemented with reliable routing packets. Node chooses reliable path based on reliability count and minimum error messages. The routes should be fault tolerant in network region. To achieve this, there are two parameters estimated to identify fault tolerability. Energy estimation is done at source and destination. The remaining energy announcement will be made by source node based on fault tolerable routes and expected transmission period.

a. Reliable Multipath Route Establishment

In this phase, multipath route is established based on embedding reliable information in every packet. In general, multiple routes are discovered and they can compensate for dynamic environment but it is unpredictable to identify the attackers inside the network zone. In the proposed multipath route establishment phase, reliable information about paths is integrated in each and every packets moving towards the destination node. Here paths are considered as disjoint one. Nodes on disjoint paths are not unique. In this work, the existing routing protocol Ad hoc On Demand Distance Vector (AODV) is modified by adding disjoint routes and less memory nodes. Packet size is larger and it is used by all the nodes. Path reliability metric is calculated and it is associated with every path. This metric is averaged trust value of mobile nodes in the particular path. The mutual reliability metric between the nodes is assumed to be asymmetric. If more number of mobile nodes deployed in the network, delay will be more and the chances of creating information alteration in the packets will also get increases. All Route Request (RREQ) and Route Reply (RREP) packets are modified and added with path reliability. If the node transmits the reliable RREQ packets, it may know only receiving packets from the destination node. The following steps illustrate the establishment of multiple routes :

Step 1 : Source node sends Reliable RREQ (RREQ) which contains *path_reliability* and it is initialized as 0. The header of RREQ is slightly altered by *path_reliability* metric i.e. given as below.

$$RRREQ : \{S_{id}, D_{id}, Seq.No., Path_{id}, Hop\} \| \; p\_reliability$$

Path reliability $(p\_reliability)$ is estimated as,

$$p\_reliability = \frac{P_{lost}}{T_{packets}} + E_{loss+transmission}$$

It is defined as the ratio of packets lost to the total packets on transmission with energy spent for packet transmission and packet loss.

Step 2: Neighbor node check the reliability of paths and hop count value and forward it to destination node.

Step 3: If the Sequence Number of the node is not matched, neighbor node will resend the RRREQ packets to source node.

Step 4: If it is matched, the message will be broadcasted to destination node. The destination node sends the reply packets containing path reliability count.

Step 5: Source node choose maximum reliability count and check the fault tolerability of the paths.

Step 6: Discover the optimized fault tolerant route with having least energy nodes on active route inside the network region.

Step 7: Route error (RERR) message will be received if the energy of node falls below the threshold value. Here the maximum transmission energy is 0.879 Joules as fixed in the simulation setup.

Step 8: Source node creates and chooses alternative path to the destination.

b. Determination of Fault tolerable routes

Once the alternative paths are setup towards the destination node, neighbor node discover the optimal paths based on the link quality estimation. The link quality can be calculated by estimating the Expected Transmission Period (ETP). This metric is used to find link capacity (*lc*) and packet size (*ps*). This ETP value will be stored in all mobile nodes including source and destination. It is given as,

$$ETP_k = ETC_k * \left({lc}/{ps} \right)$$

Where ETC is the expected transmission count for packets.

Fault Tolerable Routes (FTR) can be found as the sum of metrics of link, remaining energy, hop distance, and ETP. It is estimated as,

$$FTR = \left(\varepsilon * re_k + \phi * \frac{1}{d_{jk}} + \gamma * \frac{1}{ETP_k} + p\_reliability \right)$$

where $\varepsilon, \phi, \gamma$ are the coefficients related to remaining energy, distance between two mobile nodes and expected transmission period. Source node chooses path with maximum FTR. Source node sends RRREQ message towards the next hop. Once it is confirmed, it is able to identify the presence of destination node. The flag will be set if the destination address matches with address in the header field of RRREQ. If not, the optimal route will be constructed towards the destination node.

c. Optimized Algorithm for Energy efficiency:

Fault tolerant is major impact in MANET. To increase the stability and fault tolerability in the networks, every mobile in network should be aware of reliability count, Expected Transmission Period for transmission of packets and the availability of FTR. Energy efficiency can be improved and it must be calculated by each and every node with the help of physical layer. Remaining energy of nodes will be announced by doing the below steps.

Step 1: Source node checks the availability of FTR and ETT and chooses the route to forward the packets.

Step 2: Calculate the consumed power (P_c) at transmission side.

$$P_c = (E_r \times \tau) - (E_w \times T)$$

Where E_r is the energy required for the particular transmission and τ is the time required for energy spent on the transmission. E_w is the energy wasted on packet lost and T is the time spent for wasted energy.

Step 3: Neighbor nodes receives the status of consumed power and forward it to next hop.

Step 4: Determine the received power at the destination using reception power

$$P_r = E_{pr} \times \gamma$$

Where E_{pr} the energy is spent on packet reception and γ is the delay of packet reception.

Step 5: The remaining energy is estimated as,

Remaining Energy = Total available energy – Consumed energy on transmission and reception.

Step 6: Source node broadcast status of remaining energy to all available nodes.

d. Packet Format of RERMRS

Source ID	Destination ID	Remaining Energy	FTR	ETP	CRC
2	2	2	2	2	2

Figure 1. Packet format of RERMRS

Figure 1 shows the packet format of proposed scheme RERMRS. In this format, all the fields occupy 2 bytes. Source and destination ID are stored in the header of packet. Status of remaining energy will be announced to all neighbor node. Source and destination checks the FTR and ETP values and choose reliable routes for efficient packet transmission. CRC is Cyclic Redundancy Check for packet error checking and correction. All the nodes carry the 80 bytes packets and it should not be overloaded.

PERFORMANCE EVALUATION

The proposed scheme is evaluated using Network Simulator (NS2) tool. This tool is a event simulator using C++ language and Tool Command language (TCL). Mobility scenario is generated by using random way point model with 100 nodes in an area of 1200 m × 1200 m. The simulation settings and parameters are summarized in table 1.

Table 1. Simulation and Settings parameters of RERMRS

No. of Nodes	100
Area Size	1200 x 1200 m^2
Mac	802.11
Radio Range	100 m
Simulation Time	100 sec
Traffic Source	CBR
Packet Size	80 bytes
Mobility Model	Random Way point
Initial energy	80 Joules
Transmitted power	0.897 watts
Received Power	0.074 watts

a. Performance Metrics

We evaluate mainly the performance according to the following metrics.

Network lifetime: It is defined as the number of epochs consumed per nodes. Energy spent on transmission and reception.

Remaining energy: The energy is calculated as the difference between total available energy and consumed energy.

Energy efficiency: It is the maximum energy attained after route maintenance process.

Control Overhead: The control overhead is defined as the total number of routing control packets normalized by the total number of received data packets. It suppresses the communication between the source and destination nodes.

End-to-end delay: It depends on the routing discovery latency, additional delays at each hop and number of hops. It is normalized by means of control packets.

b. Results

Figure 2 shows the result of Energy efficiency Vs Number of nodes. From the results, our proposed scheme RERMRS achieves more energy efficiency than the existing schemes because of fault tolerable routes established from source to destination.

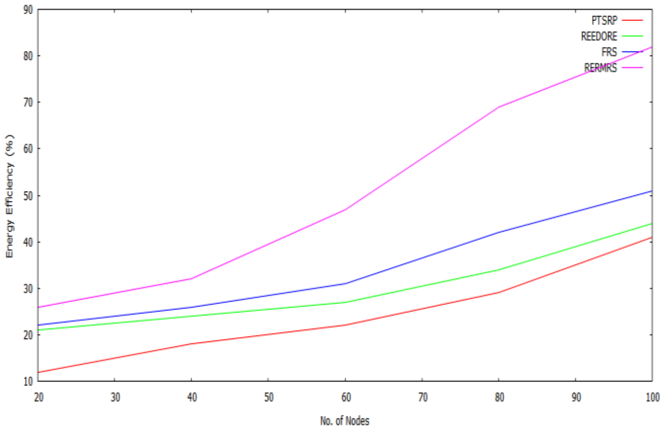

Figure 2. Energy Efficiency Vs No. of Nodes

In Figure 3, speed is varies as 10…25 bps . When we increase the speed, the mobility is also getting increasing. Mobility of nodes will lead to network partition. Vulnerability of attackers may get arises. 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 scheme RERMRS has low end to end delay per packet than the existing routing schemes i.e. PTSRP, REEDORE and FRS.

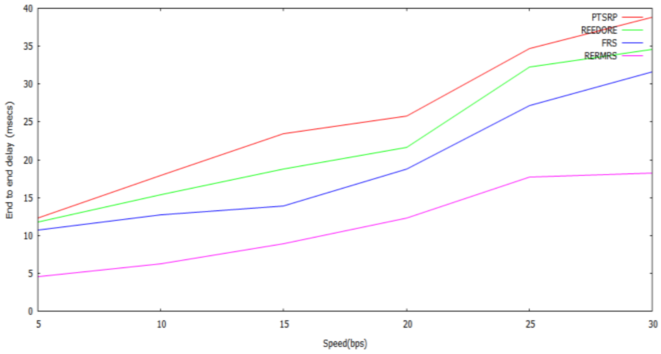

Figure 2. Speed Vs End to end delay

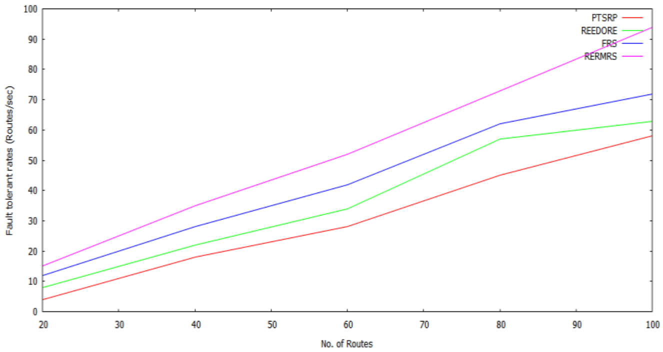

Figure 4. Fault tolerant rate Vs No. of routes

In Figure 4, number of routes is varied as 20,40….100. The fault tolerant rate of the proposed scheme RERMRS is higher than the existing schemes. Fault tolerant is achieved by means of stability and mobility. Maximum number of routes is monitored and stability is integrated with all nodes. Route Request packets are integrated with head field of RERMRS.

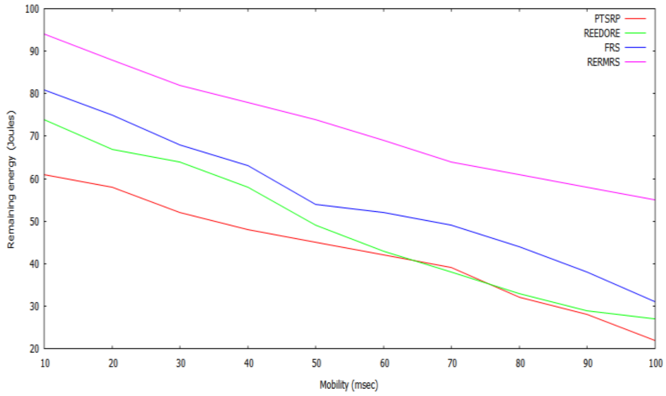

Figure 5. Remaining energy Vs Mobility

In Figure 5, Mobility is varied from 10 ms to 100 ms. Energy dissipation after route maintenance process is verified in all schemes. In proposed scheme RERMRS, it has low energy dissipation because of low packet loss rate and more fault tolerability. Remaining energy of mobile nodes is high in RERMRS.

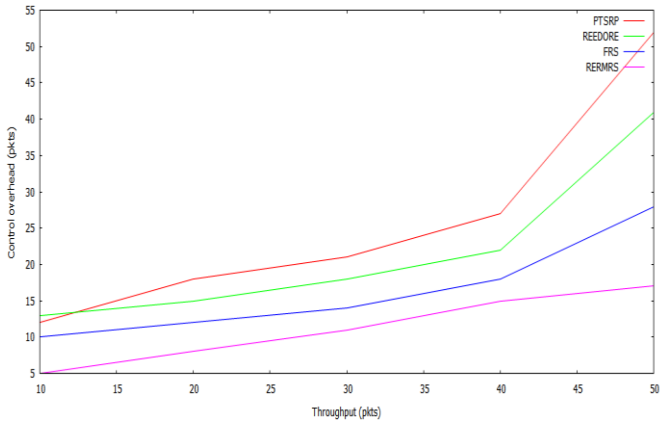

Figure 6. Control overhead Vs Throughput

In Figure 6, throughput is varied from 5 to 50 packets. Meanwhile the excessive amount of packets consumed is also verified. Compared to the existing schemes REEDORE, PTSRP and FRS, the proposed scheme RERMRS consumes less amount of control packets to initiate route discovery process and route maintenance process. It consumes low control packets and hence it has low overhead.

CONCLUSION

In this research work, remaining energy based reliable routing scheme is adopted for balancing fault tolerability and energy efficiency. All the mobile nodes are randomly moving inside and outside the network region. In this connection, nodes choose the fault tolerant parameters and expected transmission parameters for increasing energy efficiency. Remaining energy status of all nodes will be estimated and broadcasted to all neighbor nodes using multipath routes. Routes are tolerable and can withstand any network environmental effects. In future, it is planned to propose signcryption based secure multicast routing to attain network integrity and authentication.

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