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OPTIMIZED ROUTE FORMATION TECHNIQUE (ORFT) FOR DYNAMIC MANETS

[1]SNEHALATHA N, [2]PAUL RODRIGUES
[1]Assistant Professor, School of Computing, SRM University, Chennai, India
[2]Professor, Department of CSE, College of CS, KKU, Abha, Saudi Arabia
E-mail: [1]snehalatha.srm@gmail.com,

ABSTRACT

Abstract: Ever since the evolution of MANETs there has been continuous development in the research endeavors that improve the communication efficiency for the same. Although there has been so much research till date, there are so many of the MANET research issues still prevalent and hindering the smooth communication. One such issue is ambiguity and haste during route formation that not only reduces the success rate of the communication, but sometimes has a totally negative effect on the rest of the system. To avoid the packet loss during route formation and effective data delivery end-to-end, we propose a node Optimized Route Formation Technique (ORFT) using a single probabilistic method and individual node history of operations (Node Quality Factor - NQF). The ORFT method uses a simultaneous node metric evaluation process and end-to-end route evaluation process to find the best routes to destinations. Performance is analyzed using the network simulator.

Keywords: *Multi hop, Energy, Delay, Packet Processing Rate, Node Qualifying Factor, MANETs.*

1. INTRODUCTION

Mobile Ad hoc Networks is the earliest formed wireless networks right from the DARPA project when the first unethered connection was established. The wireless communication has seen vast advancement ever since the evolution of the wireless technology (Laanti et al, 2007), (Thomas et al., 2012). The majority of the research has been done in estimating the routes to the destinations using two main strategies:

- Per hop node selection
- End-to-end route selection
    - Multihop end-to-end routing (Taneja & Kush, 2010)
    - Multipath end-to-end routing (Tarique et al., 2009)

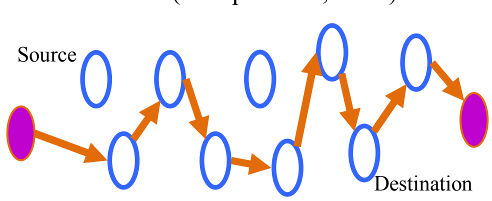

Figure 1 : Per hop selection in a MANET

The vital disadvantage of the per hop node selection is that there is the cart before the horse problem for the nodes. Each node attempts to find only its next best hop for forwarding the data and does not find short routes to the destination. For example, figure 1 shows that the per hop route formation to the destination is via a different route than in the figure 2.

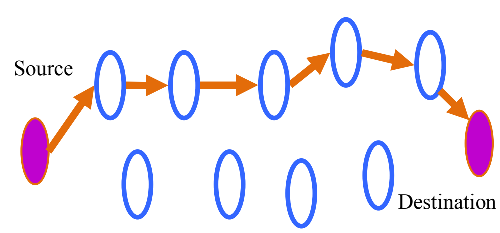

Figure 2 : Shortest Path selection in a MANET

The shortest path in a very effective route formation technique for static methods like, wireless sensor networks and wireless mesh networks. These networks do not provide dynamically moving ability and therefore simple shortest path routing could give good performance. Whereas for MANETs, where many nodes move around the topology area at the same time, shortest path routing is not very suitable due to frequent change in the link dynamics.

In this case, there is a need to introduce both per hop communication and path wise communication

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to act on a network at the same time thereby introducing performance. Therefore, in this paper we propose the Optimized Route Formation Technique (ORFT) for MANETs that use both type of communication in a single protocol to work efficiently. We compare the ORFT mechanism with the CPN-AODV mechanism to reduce the packet loss and increase delivery rate.

2. RELATED WORKS

2.1 Per Hop Communication:

Most of the methods use various metrics and averages of the same to improve routing and/ identify adversaries. In this case some of the next hop selection methods without considering the credit of the entire path are discussed here.

Potentiality Timeserving Reliable Routing (PTRR) scheme uses the acknowledgement concept to ensure the delivery of data packets (Subramanian & Logashanmugam, 2015). For every acknowledgement received consecutively the route is built by consecutive hop selection. Energy, distance and link duration are the main factors for communication establishment.

The L&TS method (Veerasamy et al, 2016) use a hop by hop trust evaluation method for providing security and the ACFG method used a path based verification to isolate malicious nodes in the network also using a node based strategy. The per hop verification in this case is used to also form routes isolating the precarious nodes although the individual metrics of a node are not involved in the entire route formation at one stretch. Per hop acknowledgement is one feature of these protocols in general.

The major disadvantage of this mechanism is that there could be looping finding routes that do not lead to the destination and excessive delay.

2.2 End to End Communication Technique:

One Most of these techniques are proactive and therefore include preselected nodes as a group of routes itself. This means that each path via which data is sent across to a network is using a path that is available before the first data packet is sent from a source to a destination.

EAR-RT (Heo et al., 2006) is a real-time routing protocol that is used to find multiple paths across the nodes. A closest next node is picked not only using the distance but also using the likelihood for the selection of the same as the next node. EAR avoids the consecutive and repeated selection of any path, thereby saving energy in the network and EAR-RT used this approach to render energy-conscious real-time routing.

The EARQ protocol (Heo et al., 2009) uses a proactive approach to form a path from the source to the destination. Although the individual metrics like residual energy, reliability, expected energy cost and time delay are estimated per hop in this mechanism, the final decision about which path to use for communication is only based on the probability of the node in successfully transmitting to the destination node using the estimated metrics. These metrics thereby provide a reason why the path should be selected to send data to the destination using a fixed set of nodes.

De Couto et al., (2003) defined the expected transmission count metric (ETX), which finds high-throughput paths on multi-hop wireless networks. ETX minimizes the expected total number of packet transmissions (including retransmissions) required to successfully deliver a packet to the ultimate destination. The ETX metric incorporates the effects of link loss ratios, asymmetry in the loss ratios between the two directions of each link, and interference among the successive links of a path. In contrast, the minimum hop-count metric chooses arbitrarily among the different paths of the same minimum length, regardless of the often large differences in throughput among those paths, and ignoring the possibility that a longer path might offer higher throughput.

AODV is a reactive protocol for which a CPN method was designed to enhance the performance. The reliability value was measured using the R_degree using the formula in equation 1 below.

$$R\_degree = \frac{\left(3 \times qmean + 2 \times \frac{1}{maxq} + 1 \times \frac{1}{nohop}\right)}{4} \quad (1)$$

The maximum queue length should not exceed the threshold maxq parameter which is used for the thresholding of the queue. And nohop is the the number of hops present in the routing. Reliability Values and select the packet with maximum route reliability. There are two major advantages in this

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method: greater flexibility to suddenly switch into a stable path and reduction in the traffic of the network. This model uses more of the Xiong's coloured petri nets (Xiong et al., 2002). The complexity of this model (CPN-AODV) is a bit high compared to that of the AODV which is a tradeoff for the efficiency. Therefore there is the need for the design of less ambiguity and haste during route formation which causes consistent loss of packets during communication. To avoid the ambiguity during route formation and effective data delivery end-to-end, we propose a node Optimized Route Formation Technique (ORFT) using a single probabilistic method and individual node history of operations under a NFQ mechanism to form a suitable and efficient dynamic route for MANETs.

3. DESIGN OF THE OPTIMIZED ROUTE FORMATION TECHNIQUE (ORFT)

The main objective of the ORFT technique is to use the individual advantages of the multi hop and end-to-end communication techniques to optimize the routes obtained by the nodes in a MANET dynamically. The proposed ORFT technique measures three major metrics while forming the route that analyze the real dynamically generating metrics of the system; and one probability based metric that justifies the selection of these metrics for route formation. The three metrics Packet Processing rate of a node, current energy and delay rate are the metrics chosen for estimation of the Node Qualifying Factor (NQF) using which parametric node is suggested.

3.1 Node Qualifying Factor (NQF)

3.1.1 Packet Processing Rate (PPn)

The packet-processing rate of a node gives the potential of the node for processing the packets. This metric reflects the capacity of the node, or in other words gives more light on the reality rather than measuring the expected capacity of a node (which leaves a lot of ambiguity in the estimation). The packet-processing rate of a node is measured using the formula in equation 2.

$$PP_n = \frac{(Recv_{PKT} - Sent_{PKT})}{Sent_{PKT}} \quad (2)$$

The PP metric clearly serves as simple and efficient metric to understand the processing rate of the node which is a less complex and straight forward metric for node performance analysis.

3.1.2 Energy of a node (En)

The energy residual in the node is nothing but the amount of energy in a node that is currently remaining in the node. This is the most connecting metric for both the delay rate and the packet processing rate as the energy of the node impacts both.

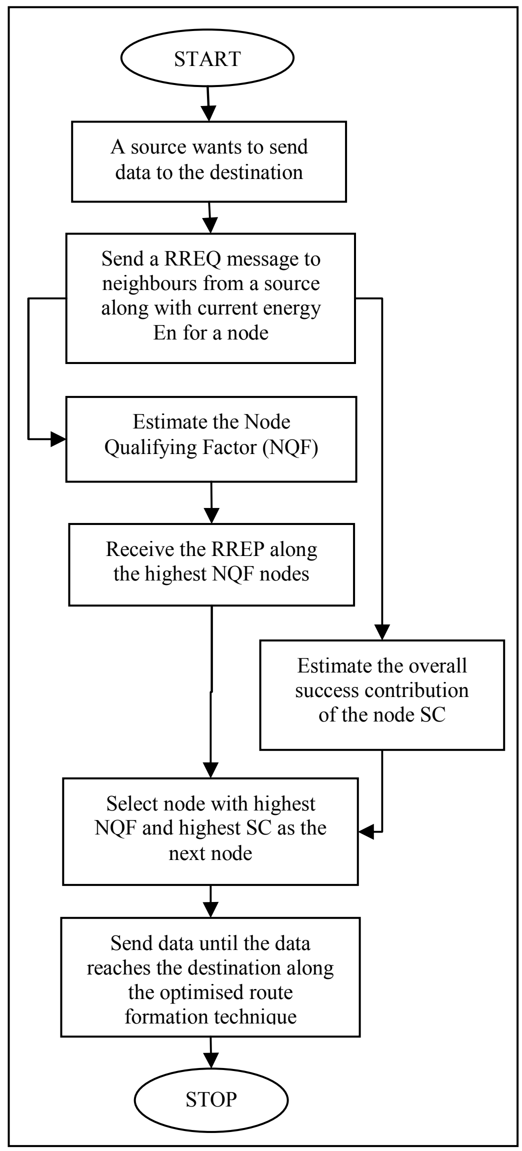

Figure 3 : Flowchart Of The ORFT For Node Selection

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3.1.3 Delay Rate (DRn)

Delay rate of a node is clearly the difference in time between the packets sent and packets received. This delay clearly gives the actual processing time for a node. It is measured in milliseconds and remains as a vital parameter to give the performance of a node using equation 3.

$$DR_n = \frac{T_{SENT} - T_{RECV}}{DR_{avg}} \qquad (3).$$

The estimation of the NQF is performed using the dynamically estimated parameters. The strategy by which routing is performed is explained pictorially using the figure 3. The figure illustrates that the source, just like in any other protocol, requires transmitting the Route Request (RREQ) message, which is in turn replied using the (RREP). The RREP message contains the energy En of a node and the delay rate DRn. Therefore, while the RREP is propagating backwards to the node, the node with the highest energy, lowest delay rate and highest packet processing rates. This is achieved by estimating the NQF value. Also another important metric is used for the probability of the success of the individual node to the overall success of the network.

3.2 Node Qualifying Factor (NQF)

The expected probability of success is estimated by the product of the probability of success of the individual nodes. This is measured using the following equation 4, using the expectation formula.

$$E[X] = \sum_{n=0}^{m} x_n p_n \qquad (4)$$

Where n – 1 hop neighbour of the current node under consideration

m – total number of neighbour nodes for current node n

xn – values that the X takes for node n

pn – probability of the occurrence of xn for node n

Clearly, the node is selecting by obtaining the product of the expectation of the probability of success of all the nodes selected consequently to form an entire route E[X] and the NQF value with the condition:

i.) 0 < Probability of Success E[X] < 1

ii.) 0 < NQF value < 1

iii.) 0 < Product of E[X] and NQF < 1

The Product of E[X] and NQF together serve in selecting the route for the formation of the route using consequent nodes. The node with the highest product value will be weaved into the route and therefore the performance of the entire network is expected to rise.

4. SIMULATION OF THE ORFT IN NS-2

The simulation of the ORFT is achieved in NS-2 where a set of nodes are deployed in MANETs topology area with those parameters in the table 1 given. The reason for the selection of the metrics as in Table 1 is to not only observe the performance of nodes moving in the random way within the topology but also validate the increase in the performance metrics over the existing CPN – AODV protocol.

Table 1: Simulation Parameters of ORFT.

Parameter	Value
Simulator	NS2(Ver. 2.28)
Simulation Time	100s
MAC	802.11
Number of nodes	50
Routing scheme	ORFT and ----
Traffic model	UDP
Simulation Area	600×600m
Transmission range	250m
Mobility model	Random way mobility model
Mobility speed	5m/s

There are many metrics used for evaluation of any protocol in a network. Packet delivery, loss and throughput are some of the main metrics used for communication performance assessment. The best way to observe whether the proposed enhancement has brought in any progress in the mechanism or

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not, is by using the constant bit rate traffic model (CBR) along with the User Datagram Protocol (UDP) in the simulation scenario. Some of the metrics used to analyze the performance of ORFT are described and evaluated in this section.

4.1 Packet Delivery Ratio

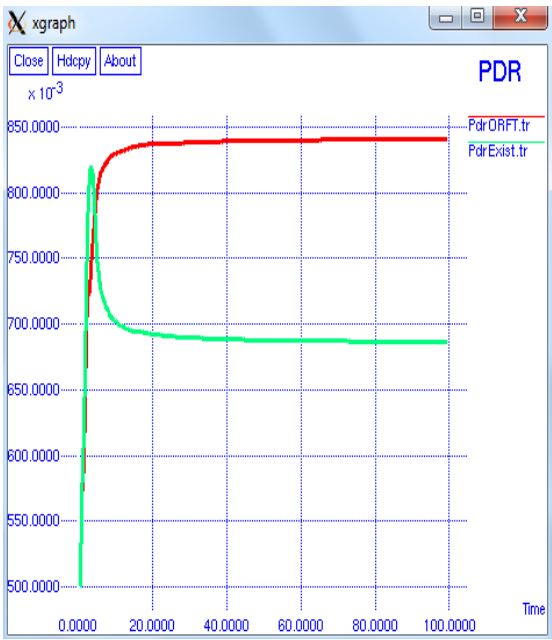

Figure 4 : Packet Delivery Ratio

The packet delivery ratio is the average packets delivered by each node to those sent by the various sources at the current point of time. In this case, we measure the PDR values of the existing and the proposed systems using the network simulator and Xgraph to obtain the graph as in the figure 4 that follows. In this graph, the ratio is a unit-less measure ranging from 0 to 1 that is found to be greater for that of the proposed mechanism (represented by the red coloured curve).

4.2 Packet Loss Ratio

Similar to the packet delivery ratio is the packet loss ratio that only measures and keeps the total number of packets lost with respect to those packets sent. Although this PLR plot in the figure 5 shows the exact contradictory plot to that of figure 4, the values are not the exact inverse. This is due to the number of experiments performed with each scenario. The figure 5 showing the PLR exhibits the improved performance of the proposed ORFT mechanism.

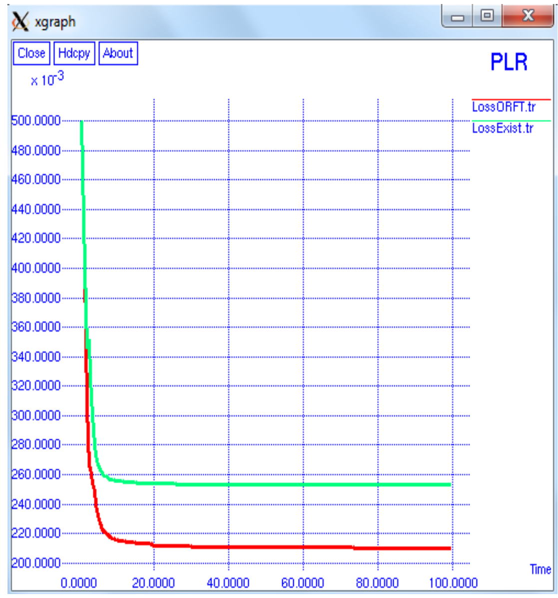

Figure 5 : Loss Ratio

4.3 Throughput

Throughput again is different from the PDR. Unlike PDR, throughput measures the total number of packets successfully delivered across the network. Figure 6 shows the plot for throughput in the ORFT and the baseline mechanisms, which shows that the ORFT mechanism has higher throughput than the existing mechanism.

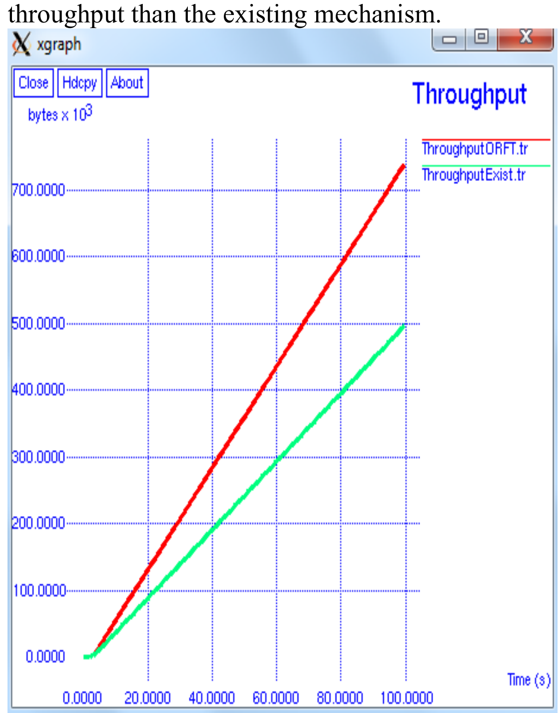

Figure 6 : Throughput

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4.4 Delay

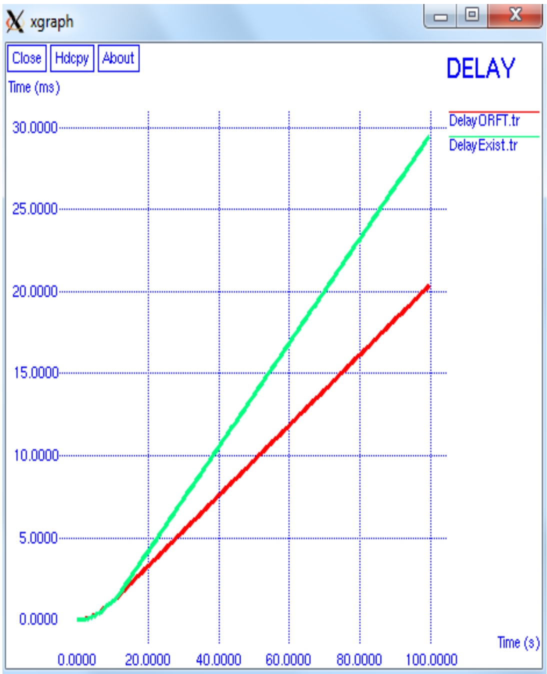

Figure 7 : Total Average Delay

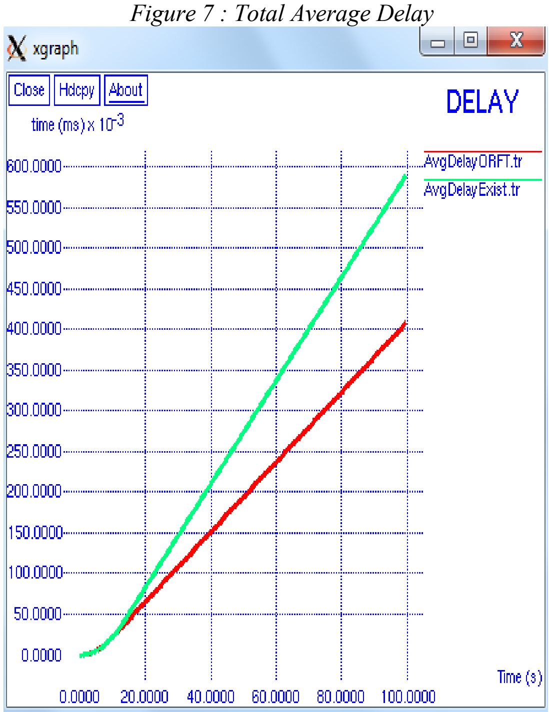

Figure 8 : Average Delay for each node

Delay is the amount of time delayed while network operations are performed. In this case, delay is measured in two terms: total average delay and average delay of a node. The total average delay is given in milliseconds in the figure 7. The total difference in the time from the sent time to the received time for each node on an average is the given in the figure 8. Both figures 7 and 8 show that the average delays are lesser for the ORFT when compared to that of the existing mechanism thereby proving the efficiency of the proposed mechanism. Delay is an important factor of the network and adds to the performance of the system.

4.5 Energy Consumption

The residual energy is measured using the energy consumption of a node for each activity. It is merely the difference between the initial energy and the final energy. From the figure 9, the average energy consumption of each node, it can be observed that the ORFT has higher energy remaining than the existing system thereby showing the efficiency of the proposed system.

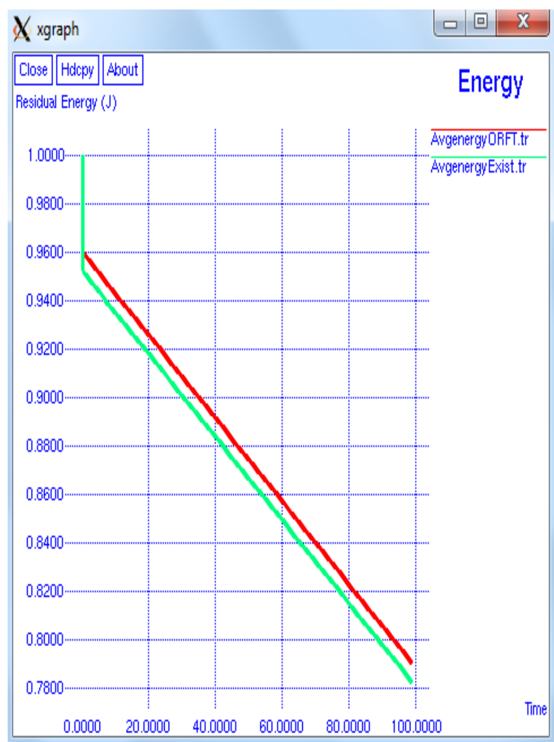

Figure 9 : Average Energy of a node

5. CONCLUSION

This paper proposed a simple and efficient method to find the route for MANET communication in highly dynamic conditions. The disadvantages of the CPN-AODV mechanism are overcome by this mechanism. The ORFT mechanism provides higher performance by giving higher packet delivery, higher average residual

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energy, higher throughput accompanied by low loss and lower delay. Therefore this is an efficient method to be used for highly dynamic MANETs. There is thus increased stability and reliability when compared to that of the existing method. In future, this technique could be studied using test bed scenarios using real ad hoc devices.

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