Prediction based Link Stability Scheme for Mobile Ad Hoc Networks

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Abstract

Mobile Ad Hoc Networks (MANETs) consist of mobile nodes which are not controlled by any base station. Mobile nodes act as a major role because of performing the data transmission, route discovery, route maintenance. The packet loss occurs often while the nodes are moving out of range, or the node has not enough either path and link stability or neighbor node stability. In this paper we propose Prediction based Link Stability Scheme (PLSS) to make a correct balance between stability of path, link, neighbor node and total mobile nodes to extend the network lifetime. The main of the proposed work is to reduce the packet loss and provide better stability using the stability model. The proposed scheme consists of four phases like determination of stability of neighbor node, link, path, total mobile nodes and prediction of total network lifetime. By simulation results the proposed algorithm PLSS achieves better performance in terms of packet delivery ratio, delay, overhead, network lifetime, energy consumption than the existing method LAER scheme.

Keywords - MANET, Link stability, Path stability, Mobility, packet delivery ratio, Network lifetime, stability weight, throughput, overhead and end to end delay.

1. Introduction

1.1. Mobile Ad Hoc Networks (MANET)

Mobile ad hoc networks could enhance the service area of access networks and provide wireless connectivity into areas with poor or previously no coverage. Some challenges that ad hoc networking faces are limited wireless transmission range, hidden terminal problems and packet losses due to transmission errors, mobility-induced route changes, and battery constraints. To enhance the prediction of the best overall performance, a network-layer metric has a better overview of the network. Ad hoc networking brings features like easy connection to access networks, dynamic multi-hop network structures, and direct peer-to-peer communication. The multi-hop property of an ad hoc network needs to be bridged by a gateway to the wired backbone. The gateway must have a network interface on both types of networks and be a part of both the global routing and the local ad hoc routing.

1.2 Fundamental aspects of Route Stability in MANET

To meet the quality of service requirements of mobile users, several metrics can be considered for selecting a source destination routing path. The fundamental aspects of Route stability are determined as follows:

1.2.1 Stable routes

To maximize throughput and reduce traffic latency, it is essential to ensure reliable source-destination connections over time. A route should therefore be selected based on some knowledge of the nodes motion and on a probability model of the path future availability.

1.2.2 Efficient route repair

If an estimate of the path duration is available, service disruption due to routefailure can be avoided by creating an alternative path before the current one breaks. Note thathaving some information on the path duration avoids waste of radio resources due to pre-allocation of backup paths.

1.2.3 Network connectivity

Connectivity and topology characteristics of a MANET are determined by the link dynamics. These are fundamental issues to network design, since they determine the system capability to support user communications and their reliability level.

1.3 Performance evaluation

The performances achieved by high-layer protocols, such as transport and application protocols, heavily depend on the quality of service metrics obtained at the network layer. As an example, the duration and frequency of route disruptions have a significant impact on TCP behavior, as well as on video streaming and VoIP services. Thus, characterizing route stability is the basis to evaluate the quality of service perceived by the users.

2. Related Work

Rajendiran M et.al [1] proposed a new energy efficient algorithm with the aim to find a stable energy multicast host against host mobility. It is done by initially identifying the energy level of individual host in MANET and then transmitting the data packets. The proposed algorithm uses adaptive function for improving reliability and choosing a stable route. The basic steps used in designing the proposed algorithm are stated as follows. Individual node energy levels were calculated. The proposed algorithm uses a power function for growing reliability and chooses a stable route direction. The objective is to define some factors that are necessary for growing reliability and to choose stable route direction.

Kai-Jie Yang and Yuh-Ren Tsai [2] proposed a new link stability prediction method based on current link-related or user-related information in shadowed environments. A more realistic user mobility model and a realistic propagation model are taken into consideration. According to the numerical and simulation results, it is found that the proposed method can accurately predict the link stability for different environment and mobility conditions. The prediction results can be regarded as a measure of the link stability, and can be applied to the applications, such as link performance prediction, system performance analysis, service quality prediction and route search. Furthermore, the impact of different mobility information on the accuracy of link stability prediction is also evaluated to assess the importance of the knowledge of mobility information.

Krunal Patel and Tejas Vasavada [3] evaluated the performance of stable and normal AODV routing under different mobility models like Random Way Point, Manhattan Model, Reference Point Group Mobility and Gauss Markov Model. Performance measures of interest were Packet Delivery Ratio (PDR) and routing overhead. It was found that RPGM results in better PDR and lowest routing overhead compared to other models. Manhattan model results in lowest PDR and highest routing overhead.

Suman halder et.al [4] introduced the novel mobility-aware routing protocol based on the well known Ad-hoc On Demand Distance Vector (AODV) routing protocol called: MA-AODV (Mobility Aware Ad-hoc On Demand Distance Vector) in an attempt to improve the handling of high mobility factor in ad-hoc networks. MA-AODV protocols performed periodic quantification of nodes mobility for the sake of establishing more stable paths between source/destination pairs, hence, avoiding the frequent link breakages associated with using unstable paths that contain high mobile nodes. The protocol reduce the topological changes, on the other hand it will also minimize the overhead of broadcasting messages. This protocol can be very efficient at the time of sending the large data where continuous connection among the source and destination is more preferable.

M.Rajendiran and S.K. Srivatsa [5] developed a multicast routing protocol based mesh networks that finds stable multicast path from source to receivers. In this model only the nodes that fulfill the delay requirements can flood the JOIN-QUERY messages. The contributing nodes are assumed to follow M/M/1 queuing systems. The queuing systems contain maximum value for queuing and contention delay which can be evaluated as the ratio of maximum queue size over the service time in a node. This model enhances link stability with contention delay and queuing system. The stable routes are found based on selection of stable forwarding nodes that have high stability of link connectivity. The link stability is calculated by using parameters link received power, distance between neighboring nodes and link quality. The performance of the proposed model is simulated over a large number of MANET nodes with wide range of mobility with two well known mesh based multicast routing protocol. It is observed that the proposed model produces better throughput and reduced overheads.

Rajashekhar C et.al [7] proposed a scheme for information priority based multiple path multicast routing in MANETs that used reliable neighbor node selection mechanism. Neighbor nodes were selected that satisfy certain threshold of reliability pair factor to find non-pruned neighbors. Non-pruned neighbors were used to establish reliable multipath multicast routes with assigned priority levels using request and reply control packets along with node database comprising of neighbor and routing information. Prioritized multipaths carry various priority data to multicast destinations. Neighbor node selection was realized with the help of node power model and mobility model. Robust route maintenance mechanism was provided to handle link and node failure situations.

Jenifus Selvarani et.al [8] evaluated the performance of Hydra and Link stability based multicast routing protocol. The main goal of this paper is to compare both the protocols with some performance metrics. Hydra elects a core for the mesh of a multicast group among the sources of the group, so that only control packets from the core are disseminated towards the receivers of a group. Hydra accomplishes this by dynamically electing a core for the mesh of a multicast group among the sources of the group, so that only control packets from the core are disseminated towards the receivers of a group. Another mesh based multicast routing protocol that finds stable multicast path from source to receivers is also presented in this paper. Data packets are forwarded through the stable paths in a mesh, which are found based on selection of stable forwarding nodes that have high stability of link connectivity.

Akbari Torkestani et.al [9] proposed a new algorithm called weighted multicast routing algorithm for MANET in which the mobility parameters are supposed to be random variable with unknown distribution. In this method, the multicast routing problem is first transformed into an equivalent stochastic Steiner tree problem in which the random weight associated with a communication link is its expected duration time. The aim of the proposed algorith m is to find the most stable multicast route (with the maximum duration) against the host mobility. The multicast routes having longer expected duration time a re more stable against the host mobility. The aim of the prop osed algorithm is to find the most stable route with the maxi mum duration among all the possible multicast paths. At eac h iteration of the proposed algorithm a multicast route is con structed by finding a random solution of the stochastic Stein er tree problem in the network topology graph. The construc ted multicast route is rewarded, if its expected duration time is longer than those of the previous iterations and it is penalized otherwise. The choice probability of the most stable multicast route converges to one as the proposed algorithm proceeds.

Sunil Taneja et.al [11] developed an effort has been made to perform analysis using random way point mobility model. The results have been derived using self created network scenarios for varying number of mobile nodes. The performance metrics used for evaluation are packet delivery ratio, average end to end delay, throughput, normalized routing load and packet loss. Proposed scheme provided the energy efficient routing over mobile ad hoc networks in a very efficient way. It assumes that all nodes are capable of dynamically adjusting the transmission power used to communicate with other nodes. Routing protocols use metrics to evaluate what path will be the best for a packet to travel. Using routing table entries and making choice between active and week nodes, it is able to select a path that is stable. This proves the optimality of the protocol. So the proposed protocol was chosen the optimal path.

Ramalakshmi et.al [14] proposed a distributed algorithm for energy efficient stable Multi Point Relay (MPR) based Connected Domain Set (CDS) construction to extend the lifetime of ad hoc wireless networks by considering energy and velocity of nodes. They have also implemented route discovery protocol to make use of the CDS nodes to relay route request messages. They proposed two rules to reduce the connected dominating size and to prolong the life span of the nodes with residual energy level and velocity.

Floriano De Rango et.al [15] explored a Link-Stability and Energy aware Routing protocol (LAER) to make a correct balance between link stability and energy efficient. Each node broadcasts HELLO packets to all its neighbors that are in its communication range; each node in LAER maintains the table of its direct neighbors. When a node receives the HELLO packet, it updates the information of the neighbor, if neighbor ID is already present in table or adds a neighbor information, if it is a new neighbor. They have not considered on path, negihbor node stability.

The paper is organized as follows. The Section 1 describes introduction about MANET, fundamental aspects of routing stability in MANET. Section 2 deals with the previous work which is related to the stability Section 3 is devoted for the implementation of prediction based link stability scheme. Section 4 describes the performance analysis and the last section concludes the work.

3. Implementation of Prediction based Link Stability Scheme (PLSS)

In the proposed PLSS scheme, there are 4 steps to achieve the predictive stability in whole network. These steps are stability of neighbor nodes, path from source to destination, calculation of mobile node stability and network lifetime prediction for a particular path. Stability is the quality which asserts the network environment's consistency. In mobile ad hoc network, nodes are continuously moving from one place to another with a certain pause-time. Stability is an important parameter in such an environment. Here comes two types of stabilities Neighbor stability and Path stability. Neighbor Stability gives an idea of the neighbor's consistency in the network while Path stability gives an idea of the path's consistency from a source node to destination. Neighbor stability helps us to find out the stable neighbor being used as a next hop node. Path stability helps us to use always a stable path for sending packets.

3.1 Stability of Neighbor Nodes

There are two parameters taken in to the consideration of neighbor nodes stability. i.e Mobility, Link loss

Path mobility is measured using packets as follows: Suppose if there are two nodes A and B then the mobility of node PQ

$$PQ_{mob} = \frac{\text{Num of packets measured from P to Q}}{\text{Num of packets measured from Q to P}} \quad (1)$$

The node link loss can be measured by using Signal to Noise Ratio. It can be measured by using bit error rate (BER) which is related to SNR as follows: Let F be the fading in the channel, given by

$$F = \frac{P_{tr}}{d^2 J} \quad (2)$$

Where d is the distance between source transmitter and destination receiver. J is the proportionality constant.
P_{tr} is the Transmitted power. Let us assume J =1, after simplifying we get,

$$F = \frac{P_{tr}}{d^2} \quad (3)$$

Fading can be also represented as the difference between transmitted and received power of source and destination mobile nodes.

$$F = P_{tr} - P_{rr} \quad (4)$$

Signal to Noise Ratio (SNR) is given as ratio of transmitted power to the noise power. It is given by

$$SNR = \frac{P_{tr}}{N_o} \quad (5)$$

If channel is fading based, Noise power is also the fading power. So the Signal to Noise Ratio (SNR) in db can be represented as:

$$SNR = 10\log(\frac{P_{tr}}{F}) \quad (6)$$

If we take it in to non logarithmic scale,

$$SNR = \frac{P_{tr}}{P_{tr} - P_{rr}} \quad (7)$$

When the noise power N_0 or fading is more, Signal to Noise Ratio decreases and Bit Error Rate also decreases. This relationship is represented by following equation.

Hence Bit error rate $P_b \alpha \frac{1}{SNR}$

$$P_b = \frac{J}{SNR}$$

$$P_b = \frac{1}{SNR} \quad \text{where } J = 1. \quad (8)$$

From the link loss with signal to noise ratio and mobility of the nodes, the stability of neighbor nodes is easily measured. The neighbor node stability is estimated by the combination of mobility and link loss of the node.

3.2 Stability of Path in Whole Network

Similarly, if there are 'n' numbers of nodes then
Mobility of path PS is measured as follows:
*Mob of path PS=Mob of PQ * Mob of QR * Mob of RS (9)*
And the link loss of the path AD is measured as follows: Link loss of path PS= link loss of PQ+ link loss of QR+ link loss of RS. Therefore, by using the two parameters the mobility and link loss, the stability of the path is measured as follows

$$S_p = \frac{M_p + LL_p}{H_c} \quad (9)$$

Where S_p = Stabilitypath
M_P = mobilitypath
LL_p = link loss path
H_c = Number of hop count

We also proposed stability of path from stability of link by following calculations. When the distance between two nodes becomes larger than the transmission range the nodes will be disconnected. For transmission range T_r link stabilityL_{sb} between any two nodes overtime period t can be calculated by:

$$L_{sb} = \frac{T_r}{\sqrt{\left\{\left(p_1^{'} - p_2^{'}\right) + t\left(n_1 \cos\theta_1 + n_2 \cos\theta_2\right)\right\}^2 + \left\{\left(q_1^{'} - q_2^{'}\right) + t\left(n_1 \sin\theta_1 + n_2 \sin\theta_2\right)\right\}^2}} \quad (10)$$

Note that L_{sb} is the link stability of individual links between any two nodes and for a path it is a concave parameter and it is same as the minimum link stability along the path. For a path from source to destination path stability P_{sb} is given by,

$$P_{sb} = Min\left(L_{sb}(1), L_{sb}(2), L_{sb}(3).......L_{sb}(N)\right) \quad (11)$$

Where 1,2,3…N is the number of links along the path.

3.3 Mobile Node Stability Calculation

The main focus of this research is to find a more number of stable nodes from source to destination and then send a data packet through stable nodes. When a mobility environment, very hard to find out a stable nodes. But this research is estimate the node stability. If every node stores signal strength information, then the stable node can easily detected. For this reason, this protocol is periodically sending HELLO packets to neighbor for detecting stable node. Every node periodically observes its neighbor node information. Based on this information a node decides which one neighbor is the stable. The main idea of behind the algorithms is when node signal strength increase, the node is close to each other. When signal strength decrease, the node is moving away. The following steps are defining the node stability:
Step 1: Every node receives the signal strength (Pr) from equation 1.
Step 2: Every node observe the neighborhood information from HELLO packet.
Step 3: Assume SSthreshmax (Signal Strength threshold) is 10 dB and SSthreshmin is 5 dB.
Step 4: Maximum transmission range of 250 meters is equivalent to 6 dB.

Step 5: Compare current signal strength Pr with $S_{Sthreshmax}$ and $S_{Sthreshmin}$.
Step 6: If (P_r <= SSthreshmax) & (P_r >= SSthreshmin) , then the neighbor node is more stable.
Step 7: Update 1 in signal strength table
Step 8: If Pr < SSthreshmin, then the neighbor node is un stable.
Step 9: Update 0 in signal strength table.
Step 10: Assume destination node maintain more stable list in their signal strength table.

3.4 Network Lifetime Prediction for a Particular Path

For n paths (π_1, π_2,….π_n) from source to destination, lifetime of a path is bounded by the lifetime of all the nodes along the path. When a node dies along a path we can say that the path does not exist any longer. So we can consider the lifetime of a path is a concave parameter and it is the same as the minimum lifetime among all the nodes along the path. The lifetime of a path π_j can be defined as:

$$\tau_j = Min\left(T_k(t).....\{k \in j\}\right) \quad (11)$$

$T_k(t)$: predicted lifetime of node k in path π_j
The cost of a path is the sum of all the minimum costs calculated between two consecutive nodes along the path from source
to the destination. Minimum Cost of a path πi can be defined as:

$$\varsigma_j = \sum_{k=1}^{\pi_{j_m}=1} v_{\pi_{j_{k,k+1}}}(t) \quad (12)$$

Where π_{jm} is number of nodes in path $v_{\pi jk}$ is the cost between node k and k+1 of the path πi. We represent the cost effective predicted lifetime L_{plt} by:

$$L_{plt} = \frac{\tau_j}{\varsigma_j} \quad (13)$$

3.5 Proposed Packet Format

Source Address	Dest. Address	Path Lifetime	Node Stability	SNR	BER	Hop count
2	2	4	4	2	2	1

Fig.1 Proposed Packet format

In fig 2, the packet format of proposed algorithm is shown. Here the first two fields source and destination address occupies 2 bytes. The third field occupies 4 byte field where the path life time of a node. In next field, Node stability fills 4 byte. SNR occupies 2 byte field. BER occupies 2 byte field. Finally the Hop count occupies 1 byte field for calculating number of hops from cluster node.

4. Performance Analysis

We use NS3 to simulate our proposed PLSS algorithm. In our simulation, 200 mobile nodes move in a 1200 meter x 1200 meter square region for 50 seconds simulation time. All nodes have the same transmission range of 250 meters. The simulated traffic is Constant Bit Rate (CBR). Our simulation settings and parameters are summarized in table 1

Table1. Simulation and settings parameters

No. of Nodes	200
Area Size	1200 X 1200
Mac	802.11
Radio Range	250m
Simulation Time	80 sec
Traffic Source	CBR
Packet Size	80 bytes
Mobility Model	Random Way Point
Propagation model	Two Ray ground
Packet Rate	5 pkts/s

4.1 Performance Metrics

We evaluate mainly the performance according to the following metrics.

Control overhead: The control overhead is defined as the total number of routing control packets normalized by the total number of received data packets.

Packet Delivery Ratio: The packet delivery ratio (PDR) of a network is defined as the ratio of total number of data packets actually received and total number of data packets transmitted by senders.

Normalized Path Discovery: Normalized path discovery is defined as the number of RREQ packets generated per data packet.

End-to-End Delay: The End-to-End delay is defined as the difference between two time instances: one when packet is generated at the sender and the other, when packet is received by the receiving application.

The simulation results are presented in the next part. We compare our proposed algorithm PLSS with LAER [15] and in presence of stability environment.

Figure 2 shows the results of average end-to-end delay for varying the speed from 20 to 100. From the results, we can see that PLSS scheme has slightly lower delay than the LAER scheme because of stable routing.

Fig. 3, presents the energy consumption while varying the stability wight. The Comparison of LAER, PLSS energy consumption is shown. It is clearly seen that energy consumed by PLSS is less compared to LAER.

Fig. 4, presents the comparison of overhead. It is clearly shown that the overhead of PLSS has low overhead than LAER scheme.

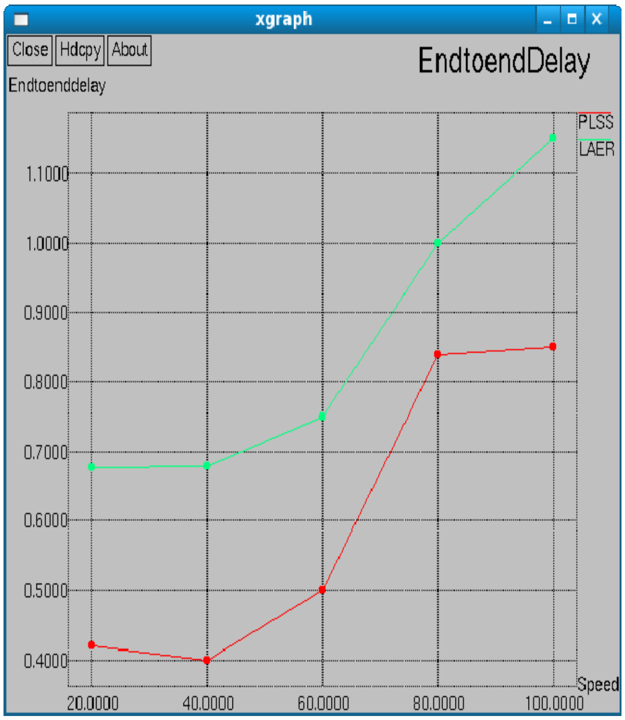

Fig. 2. Speed Vs End to end Delay

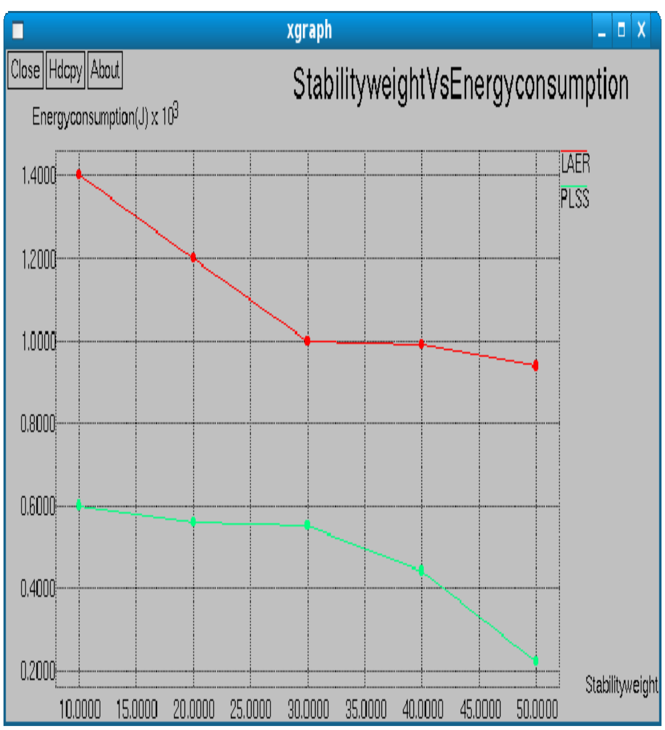

Fig. 3. Stability Weight Vs Energy Consumption

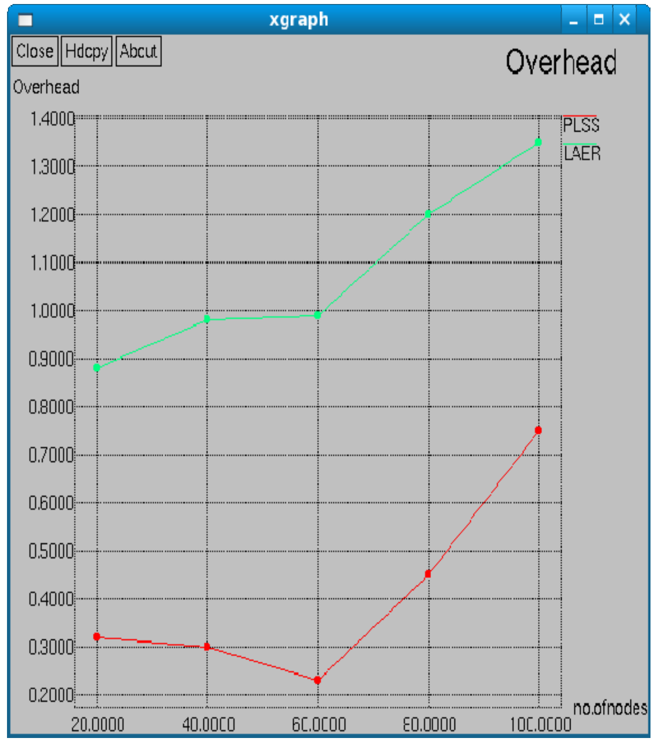

Fig. 4. No. of nodes Vs Overhead

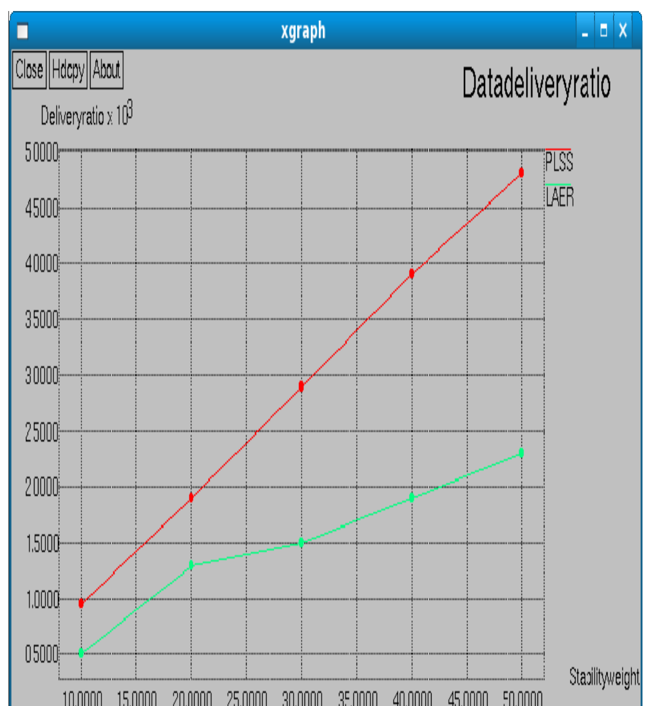

Fig.5. Mobility Vs Packet Delivery Ratio

Figure 5 show the results of average packet delivery ratio for the stability weight 10, 20…50 for the 200 nodes scenario. Clearly our PLSS scheme achieves more delivery ratio than the LAER scheme since it has both reliability and stability features.

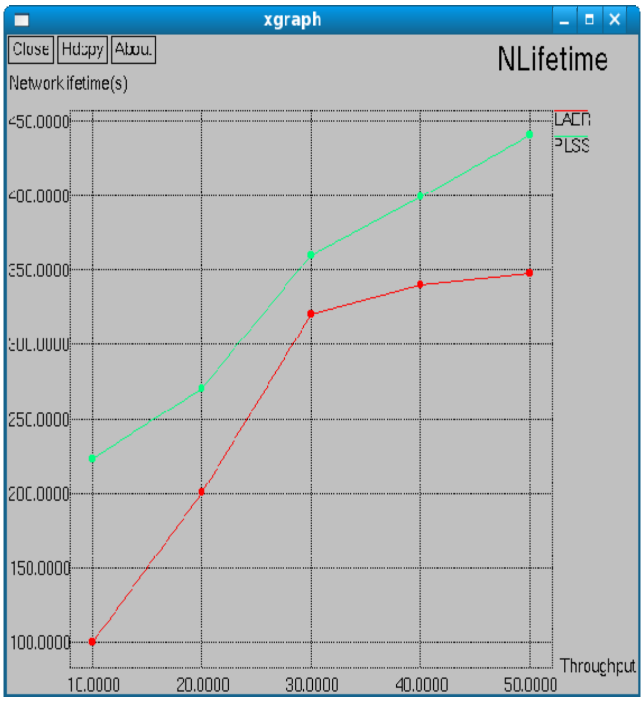

Fig.6. Throughput Vs Network Lifetime

Figure 6 show the results of average network lifetime for the throughput 10, 20…50 for the 200 nodes scenario. Clearly our PLSS scheme achieves more network lifetime than the LAER scheme since it has both predicting stability features.

5. Conclusions

In MANET, mobile nodes are moving randomly without any centralized administration. If these nodes are not having reliable stability of neighbor nodes, links, paths from source to destination, it will suffer more loss in link. In this paper, we have developed a prediction based stability scheme with stability models which attains stability in link, path and neighbor nodes. In the first phase of the scheme, stability of neighbor nodes is achieved using mobility and stability of paths. In second phase, stability of path is achieved. It uses three factors called mobility factor, link stability, link loss to favor packet forwarding by maintaining stability for each path. In third phase, stability of total mobile nodes is reached using the threshold signal strength value. In fourth phase, we predicted the network lifetime of the whole network. By simulation results we have shown that the PLSS achieves good packet delivery ratio, more network lifetime while attaining low delay, overhead, minimum energy consumption than the existing scheme LAER scheme while varying the number of nodes, node speed, throughput and stability weight.

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