DYNAMIC BEHAVIOURAL ROUTING PROTOCOL FOR LONGEST ROUTE LIFETIME PREDICTION IN MANET

Raguvaran.S
Department of CSE (PG)
Sri Ramakrishna Engineering College
Coimbatore, India

Kanagaraj.R
Department of CSE (PG)
Sri Ramakrishna Engineering College
Coimbatore, India

***Abstract* -In MANETs, the network's wireless topology may be unpredictable and may change rapidly. The widely varying mobility characteristics are expected to have significant impact on the performance of the routing protocol. A host may lose its energy or roam independently without informing to its cooperative nodes, causing changes in network topology, and thus, these changes cause overwhelming affect in the routing protocol's performance. Plenty of researches have been done to analyze node lifetime and link lifetime to address this problem. Here, the dynamic behavior of mobile nodes such as the energy depletion rate and the relative mobility computation are used to develop a new algorithm to compute the node lifetime and the link lifetime of mobile nodes. Combining these two intuitive performance metrics and by using the proposed route lifetime-prediction algorithm, resulting in the selection of the least dynamic route with the longest lifetime for persistent data forwarding. Finally, the proposed route lifetime-prediction algorithm is implemented in a dynamic behavioral routing protocol environment based on Dynamic Source Routing (DSR) protocol. The main advantage of EDNR protocol is improving the throughput, reducing the time delay and route failures by finding Route Life Time (RLT) to achieve the persistent data forwarding. This protocol is compared with the traditional protocols like Lifetime-Prediction Routing (LPR) and Signal-Stability-based Adaptive (SSA) routing mechanisms to imply its advantages over the others.**

***Index Terms*– Lifetime Prediction, Link Lifetime (LLT), Mobile Ad-hoc Networks (MANETs), node lifetime, route discovery, routing protocol.**

I. INTRODUCTION

A MANET has many mobile nodes. In MANET, communication between the nodes happens directly or through intermediate nodes. Nodes don't have constant power supply .They work with batteries and move independently without informing to its neighboring nodes. Since nodes are roaming frequently, a node may exhaust its power or move beyond the communication range, and leads to topology change in the network. Toh [2] proposed selecting a path which consists of nodes with sufficient battery power and minimum total transmission power when there exist some possible paths. Misra and Banerjee [3] proposed selecting a path that has the maximum data transmission capacity (the residual battery power divided by the expected energy spent in reliably forwarding a packet) at a "critical" node among multiple paths. Shrestha and Mans [4] mentioned that the neighboring dataflow also affects the energy depletion rate of a node. These studies often attempt to find a stable route that has a long lifetime [5].These solutions are classified into two main groups: node lifetime routing algorithms and link lifetime (LLT) routing algorithms. Marbuhk and Subbarao [6] proposed selecting a path according to the remaining battery life of nodes along the route to maintain longest network connectivity. In the signal stability-based adaptive (SSA) routing [7], each link is categorized as a strong one or a weak one, depending on the received signal strength measured when a node receives data packets from the corresponding upstream node. In the associativity-based routing algorithm [8], a link is considered to be stable when its lifetime exceeds a specific threshold that relies on the relative speed of mobile hosts. The critical node is the node that has the smallest packet transmission capacity in a path. In the lifetime-prediction routing (LPR) algorithm [9], each node estimates its battery lifetime based on its residual energy and its previous activity. Gerharzet al. [10] computed the lifetime of a link between two neighboring mobile hosts through online statistical analysis of the measured links. Tickoo et al. [11] computed the uncertainty of a link by observing the difference of the received signal strengths of consecutive packets flowing from the same origin to find if these two nodes are getting closer or moving apart. As a different approach, Wu et al. [12] used a two state Markovian model to reflect the mobility of nodes and compute the link behaviors.

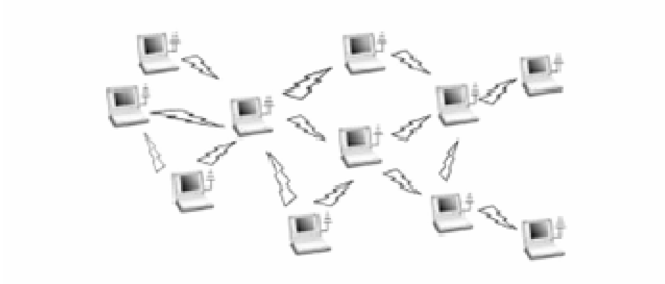

Fig 1: An example of mobile ad-hoc network

II. ROUTE LIFETIME-PREDICTION ALGORITHM

A route which consists of multiple links in series is broken when a single link among the route is broken. And hence the lifetime of the route becomes minimum lifetime of all links in the route. Given two neighboring mobile hosts located in cells (x,y) and (x',y'), respectively, the wireless link from the former to the latter is denoted by a vector (x'-x, y'-y). Thus, a routing path can be regarded as a sequence of vectors, each representing one wireless link. For example, a routing path connecting hosts in cells(0,1),(3,1),(7,-3) can be written as (3,0),(4,-4).

A link is broken if any of the two nodes in the link is not alive due to exhaustion of energy or if these two nodes move out of each other's communication range. Connection and node lifetime to distinguish between the two cases described above.

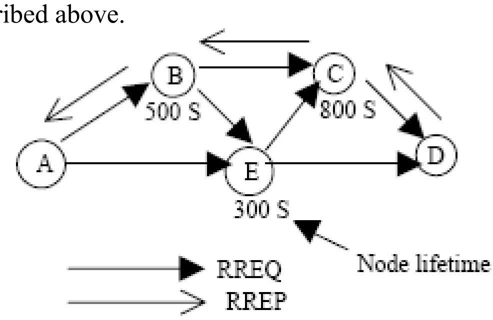

Fig 2: Route Setup Process

In this paper, a link is constructed by two nodes in a connection and the connection itself, and the LLT depends on both the node lifetime and the connection lifetime. Route set up process in our proposed approach is shown in figure 2 above.

A link L_i is constructed by a connection C_i and two nodes (N_{i-1},N_i), the connection between nodes N_i-$_1$ and N_i is denoted as C_i, and it is constant until the adjacent nodes (N_{i-1},N_i) move beyond the communication range under the consideration of no energy problem in both nodes N_i-$_1$ and N_i. The estimated lifetime of the connection C_i represented as TC_i, and it only depends on their relative mobility and distance of nodes N_i-$_1$and N_i at a given time. The estimated battery lifetime of node N_i is denoted as TN_i . Then, the lifetime of the link L_i is computed as the minimum value of (TC_i, TN_i-$_1$,1TN_i),ie.,

$$TL_i=\min(TC_i,TN_{i-1}, TN_i) \qquad (1)$$

Consider as an example a route P consisting of n links. Route P is said to be broken if any one of the following cases occurs. First, any one of the nodes in the route dies due to insufficient battery energy. Second, any one of the connections is lost because the corresponding two adjacent nodes move beyond the communication range. Thus, the lifetime of route P is computed by the minimum value of the lifetime of both nodes and connections involved in route P. Consider that Ω represents the set of all nodes in route P and that Ψ is the set of all the connections in route P. Thus, the lifetime T_p of route P can be expressed as

$$T_p=\min_{N_i \in \Omega, C_i \in \Psi}(TN_i,TC_i) \qquad (2)$$

From(2), the lifetime T_p of route p is computed from the measured lifetime of each node and each connection.

A. Node Lifetime Prediction

Assume, two nodes that have the same residual battery power, a node which is involved in numerous data-forwarding paths consume energy more quickly. Hence, it has a shorter lifetime rather than the remaining inactive node. By using the same method as described in [9], the lifetime of the node is calculated that is based on its current residual battery power and its past activity. Here, a much simple solution has been proposed that facilitates in avoiding the computation of node lifetime for each data packet.

The term E_i represents the current residual battery power of node i, and e_{vi} is the energy depletion rate. The online battery management instrument provides the E_i, and e_{vi} is the statistical value that is obtained from recent history. The energy depletion rate e_{vi} is computed by an exponentially weighted moving average method. Every T seconds (the smaller the value of T, the more accurate this algorithm is), node i reads the current residual battery power value $E_i^0, E_i^{2T}, E_i^{3T}, E_i^{(n-1)T}, E_i^{nT}$, in every period[0, T], [T, 2T], [2T, 3T], . . . , [(n − 1)T, nT] . . ., and the corresponding estimated energy depletion rate ev_i is computed as

$$\begin{cases} ev_i^0 = 0, & n=0 \\ ev_i^1 = \left(E_i^0 - E_i^T\right)/T, & n=1 \\ ev_i^n = \alpha\left(E_i^{(n-1)T} - E_i^{nT}\right)/T + (1-\alpha)ev_i^{n-1}, & n>1 \end{cases}$$

[3]

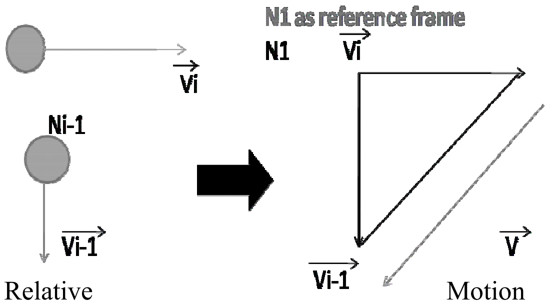

Fig. 3 Relative Motion

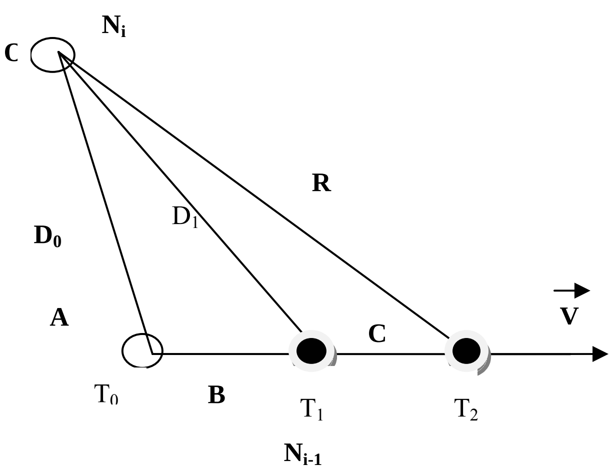

Fig.4 LLT prediction algorithm

Where ev_i^n is the estimated energy depletion rate in the n^{th} period, and ev_i^{n-1} is the estimated energy depletion rate in the previous $(n-1)^{th}$ period. α indicates the coefficient that provides the relation between ev_i^n and ev_i^{n-1}, and it is a constant value between [0, 1]. In this algorithm, to provide the current condition of node i, a higher priority is granted to ev_i^n and set α = 0.6.At time t, we can the estimated node lifetime as follows:

$$T_{Ni} = E_i^{nT} / ev_i^n, \quad t€[nT, (n + 1)T] \qquad (4)$$

B. Connection Lifetime-Prediction Algorithm

The LLT is evaluated using the connection lifetime; however, it is difficult to predict the connection lifetime T_{Ci} between two nodes (N_{i-1},N_i) because the nodes in MANETs may move independently. The connections that are in an unstable state and may only last for a short period particularly are handled in our algorithm, ignoring the stable one for simplicity. The following are the reasons: First, only the minimum node lifetime or the connection lifetime in a route is considered. Since two nodes of a persistent connection are within the communication range of each other, the connection lifetime may last longer, and they do not affect the route to which they belong. Second, modeling the mobility of nodes in a short period during which unstable connections last is much easier task. We can assume reasonably and simply that the nodes move at a constant speed toward the same direction during a short period of time.

The connection lifetime T_{Ci} depends on the relative motion between N_i and N_{i-1}, and the connection is said to be broken when two nodes (N_{i-1},N_i) roam beyond the radio transmission range R. Basically, there are two mandatory tasks here. One is how to measure the distance between nodes N_i and N_{i-1}, while the other is how to estimate the relative velocity of these two mobile nodes. When Global-Positioning-System-based location information is used it is easy to measure the distance between nodes Ni and N_{i-1} and then calculate it just as described. Here, a simple method has been proposed, in this approach, Assuming that senders transmit packets with the constant power level, a receiver can measure the received signal power strength when receiving a packet and then compute the distance by directly applying the radio propagation model. If the received signal power strength is lower than a threshold value, this link is regarded as an unstable state and then the connection time is calculated.

Fig. 3 illustrates the relative motion of two nodes (N_{i-1}, N_i) moving at relative velocities V_i and V_{i-1} relative to ground at a given time t. The ground is used as a reference frame by default. If node N_i is considered as the reference frame, node N_{i-1} is moving at a relative velocity of V, as given by the following:

$$\vec{V} = \vec{V}_{i-1} - \vec{V}_i \qquad (5)$$

To estimate the connection lifetime T_{Ci}, a triangle geometry theory is applied and the method is improved that needs three sample packets and estimates the link expiration time for proactive route maintenance in the previous work. Our proposed method needs only two sample packets, and piggyback information is implemented on route-request (RREQ) and route-reply (RREP) packets during a route-discovery procedure without control message overhead, and thus, it does not increase time complexity.

III. EDNR PROTOCOL

In MANETs, DSR is the most popular routing protocol and it is easy to extend the routing control message format of DSR. Here, the route lifetime-prediction algorithm has been proposed and implemented in the DSR protocol. The proposed algorithm comprises the following three phases: route discovery, data forwarding, and route maintenance.

There are three main differences between the EDNR and the DSR. First, in the EDNR protocol, every node records the received signal strength and the received time of the RREQ packet in its local memory, and stores this information into the RREP packet header in a piggyback manner when it receives the RREP for the corresponding RREQ packet to meet the requirement of the connection lifetime-prediction algorithm. Second, for every time period node agents should update their predicted node lifetime. Finally, the information of node-lifetime in the RREP packet is updated when the RREP packet is returned from a destination node to the source node. At every EDNR node agent, a variable NLT, which represents the node lifetime, is added to indicate the estimated lifetime of this node, and it is updated by the algorithm. Three new entries, i.e., path lifetime (PLT), RREQ time, and RREQ signal strength, are recorded to the common header of an RREP packet. The PLT indicates the computed lifetime of the source route in this packet header and can be updated when RREP packets are forwarded from the destination node to the source node in the route-discovery phase. The RREQ time and the RREQ signal strength represent the RREQ_ Info of the previous RREQ node. The EDNR node agent only updates the PLT value in the common header of the RREP packet with a local NLT value or LLT value, if NLT <PLT or LLT <PLT, before forwarding this RREP packet.

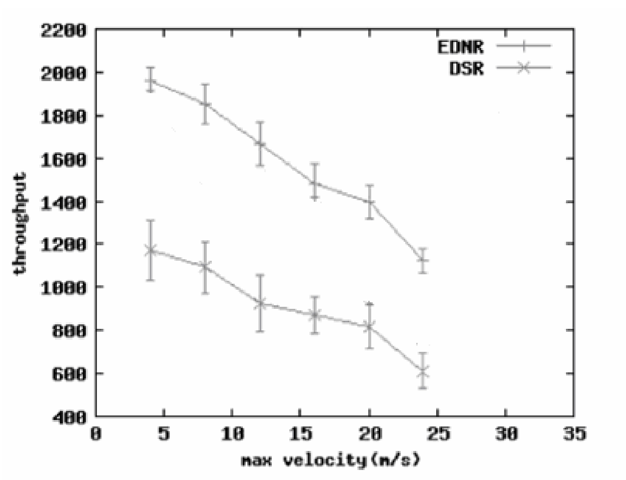

Fig.5 Throughput

When the source node receives this RREP packet, the value of PLT reaches to the minimum value of the estimated lifetime of all nodes and links through the route from the source node to the destination node. During the persistent data forwarding period, a source node tends to select the path with the longest lifetime (the path with the maximum PLT value) from multiple paths as a source route for data forwarding.

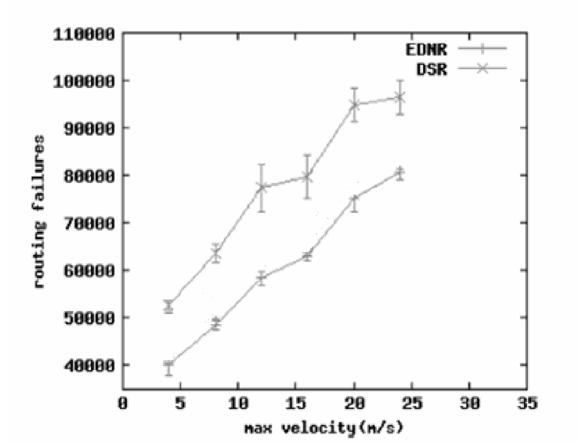

Fig 6: Number of Routing Failure

IV. PERFORMANCE EVALUATION

A. Simulation Environment

For our simulations, we use a GloMoSim simulator. To compute the impact of mobility on the performance of routing protocols, the mobility of nodes follows a random way-point model. A mobile node begins a trip to a random destination at a constant speed chosen from a uniform distribution, then holds for a predefined pause time, and starts another trip to a random destination again. The initial energy is similar to previous studies, and simulation time is set to 1000 s, which is different from that because the time of the first node is employed which is broke down as the criterion of the network lifetime, whereas the network lifetime is the time taken for a fixed percentage of the nodes to die. Each data point indicates an average of five different randomly generated mobility models. The confidence level is set to 95%, and the confidence interval is shown as a vertical bar in the figures (Figs.5-7). Table I provides the more detailed simulation parameter values.

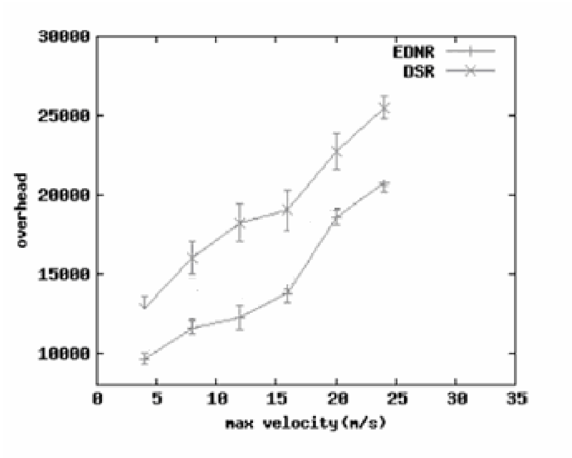

Fig 7: Routing Overhead

Table 1: Simulation parameters

Simulation Time	1000s
Topology Size	1000m x 1500m
Number of Nodes	100
MAC Type	MAC 802.11
Radio Propagation Model	Two Ray Ground
Radio Propagation Range	250 m
Pause Time	0 s
Max Speed	4m/s-24m/s
energy Model	Energy Model
Initial Energy	100 J
Transmit Power	0.4 W
Receive Power	0.3 W
Idle Power	0 W
Traffic Type	CBR
CBR Rate	512 Bytes x 6 per second
Max Number of Connection	50

C. Simulation Results

To compute the performance of the EDNR, the performance of the EDNR is compared with the original DSR protocol, based on the following: network throughput, routing failures, and control packet overhead. Usually, the original DSR find the shortest path from the source node to the destination node, ignoring the node lifetime and wireless LLT. The LPR mechanism facilitates to find a stable route by using the node lifetime based on residual battery power and previous activity. The SSA mechanism computes the wireless LLT by classifying neighbors into a strongly connected set and a weakly connected set, and it drops the RREQ from weakly connected neighbors. In general, the LPR mechanism performs better in a low-mobility scenario, whereas the SSA mechanism seems to be more suitable for a high-mobility scenario.

V. CONCLUSION AND FUTURE WORK

In MANETs, a link is made by two adjacent mobile nodes, which have limited battery power and can roam independently, and the link is said to be broken if any of the nodes dies because of insufficient battery power or they move beyond the communication range. The node lifetime and the LLT are considered to predict the route lifetime and have proposed a new algorithm that explores the dynamic behavior of mobile nodes, such as the energy depletion rate and the relative motion estimation rate of nodes, to compute the node lifetime and the LLT. Combining these two intuitive performance metrics and by using the proposed route lifetime-prediction algorithm, resulting in the selection of
the least dynamic route with the longest lifetime for persistent data forwarding. Finally, the proposed route lifetime-prediction algorithm is implemented in a dynamic behavioral routing protocol environment based on Dynamic Source Routing (DSR) protocol. The main advantage of EDNR protocol is improving the throughput, reducing the time delay and route failures by finding Route Life Time (RLT) to achieve the persistent data forwarding. We have computed the performance of the proposed EDNR protocol based on the DSR. Simulation results show that the EDNR protocol performs better than the DSR protocol implemented with LPR and SSA mechanisms.

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AUTHORS PROFILE

Mr.S.Raguvaran completed B.E in Computer Science and Engineering from kongu engineering College in May 2008.currently pursuing M.E in Software Engineering in Sri Ramakrishna Engineering College.

Mr.R.Kanagaraj received B.E degree in Computer Science and Engineering from Coimbatore Institute of Technology in May 2006 and M.E Computer Science and Engineering from Anna University of Technology, Coimbatore. Currently working as an Assistant Professor in Sri Ramakrishna Engineering College. His research interest is cloud computing