Enlarging the Network Lifetime for Continual Data Forwarding with Dynamic Route by using Route Lifetime-Prediction Algorithm

S. P. Santhoshkumar #[1], B.Santhoshkumar#[2], D. Prabakar #[3], Dr. S. Karthik#[4]

[1#] *Assistant Professor, Dept of CSE, SNS College of Technology-India*
E-Mail ID: spsanthoshkumar@gmail.com
[2#] *Assistant Professor (SG), Dept of CSE, SNS College of Technology-India*
E-Mail ID: b.santhoshkumar@gmail.com
[3#] *Assistant Professor, Dept of CSE, SNS College of Technology-India.*
E-Mail ID: prabakaralam@gmail.com
[4#] *Professor & Dean, Dept of CSE, SNS College of Technology-India.*
E-Mail ID: profskarthik@gmail.com

Abstract — **Mobile ad hoc network is defined as a transient network which is formed dynamically by the collection of nodes which are arbitrary. It can also be called as infrastructure less network, because it has no structure frame for positioning the nodes, these nodes are combined and this union forms a random topology. In this kind of network, node itself acts and does the work of router in routing the packets. When a network partition occurs, mobile nodes in one partition are not able to access data hosted by nodes in other partitions, so it significantly degrade the performance of data access. To deal with this problem, uses different data replication techniques. Data replication is either reducing the query delay or improving the data availability, but not both. An improved routing will increase the data availability and reduce the query delay. A host may exhaust its power or moving to other place without giving any notice to its cooperative nodes. Thus the performance of routing protocol is degraded. The protocol studies based on node lifetime and link lifetime have been done to address this problem. To combine these two performance metrics by using the proposed route lifetime-prediction algorithm, the least dynamic route with the longest lifetime used for continual data forwarding. At last, our proposed route lifetime-prediction algorithm in an Ad hoc On-Demand Vector (AODV) protocol environment and compare the performance through simulations.**

Key words — Data availability, Lifetime prediction, link Lifetime (LLT), Query delay.

I. INTRODUCTION

Mobile ad-hoc network is a self-configuring network of wireless links connecting mobile nodes. These nodes may be routers and/or hosts. The mobile nodes communicate directly with each other and without the aid of access points, and therefore have no fixed infrastructure. They form an arbitrary topology, where the routers are free to move randomly and arrange themselves as required. Each node or mobile device is equipped with a transmitter and receiver. They are said to be purpose-specific, autonomous and dynamic. This compares greatly with fixed wireless networks [5], as there is no master slave relationship that exists in a mobile ad-hoc network. Nodes rely on each other to established communication, thus each node acts as a router. Therefore, in a mobile ad-hoc network, a packet can travel from a source to a destination either directly, or through some set of intermediate packet forwarding nodes.

A. Routing Protocols

A routing protocol is needed whenever a packet needs to be transmitted to a destination via number of nodes and numerous routing protocols have been proposed for such kind of ad hoc networks. These protocols find a route for packet delivery and deliver the packet to the correct destination. The studies on various aspects of routing protocols have been an active area of research for many years [7]. Many protocols have been suggested keeping applications and type of network in view. Basically, routing protocols can be broadly classified into two types as (a) Table Driven Protocols or Proactive Protocols (b) On-Demand Protocols or Reactive Protocols.

B. Table Driven or Proactive Protocols

In Table Driven routing protocols each node maintains one or more tables containing routing information to every other node in the network. All nodes keep on updating these tables to maintain latest view of the network [8]. Some of the existing table driven or proactive protocols are: Destination Sequence Distance Vector (DSDV), Wireless Routing Protocol (WRP), etc.

C. On Demand or Reactive Protocols

In these protocols, routes are created as and when required. When a transmission occurs from source to destination, it invokes the route discovery procedure [11]. The route remains valid till destination is achieved or until the route is no longer needed. Some of the existing on demand routing protocols are: Dynamic Source Routing (DSR), Ad hoc on demand Distance Vector (AODV), etc.

D. Ad Hoc On-Demand Distance Vector (AODV) Protocol

When a node wants to send a data packet to a destination node, the entries in route table are checked to ensure whether there is a current route to that destination node or not. If it is there, the data packet is forwarded to the appropriate next hop toward the destination. If it is not there, the route discovery process is initiated. AODV initiates a route discovery process using Route Request (RREQ) and Route Reply (RREP). The source node will create a RREQ packet containing its IP address, its current sequence number, the destination's IP address, the destination's last sequence number and broadcast ID [8].

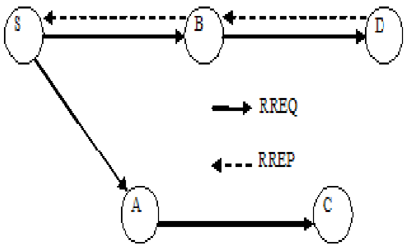

Figure.1 Route Discovery in AODV

The broadcast ID is incremented each time the source node initiates RREQ. Basically, the sequence numbers are used to determine the timeliness of each data packet and the broadcast ID & the IP address together form a unique identifier for RREQ so as to uniquely identify each request in figure 1. The requests are sent using RREQ message and the information in connection with creation of a route is sent back in RREP message. The source node broadcasts the RREQ packet to its neighbours and then sets a timer to wait for a reply. To process the RREQ, the node sets up a reverse route entry for the source node in its route table. This helps to know how to forward a RREP to the source. Basically a lifetime is associated with the reverse route entry and if this entry is not used within this lifetime, the route information is deleted [4]. If the RREQ is lost during transmission, the source node is allowed to broadcast again using route discovery mechanism.

II. RELATED WORK

A Lifetime Prediction Routing

In the lifetime-prediction routing (LPR) algorithm [5], each node attempts to estimate its battery lifetime based on its residual energy and its past activity. It maximizes the network lifetime by finding routing solutions that minimize the variance of the remaining energies of the nodes in the network. The above algorithm used well-defined metrics to evaluate the lifetime of nodes.

B Maximum Survivability Routing

Marbuhk and Subbarao [3] aimed to preserve network connectivity by choosing a route according to the remaining battery life of nodes along the route. Network is to prolong connectivity for *every* node, and then the routing should avoid transmitting through the node with the *least* remaining battery life. However, this routing “around” approach requires large *total* power expenditures due to an increase in the number of hops or distance between transmitting nodes. If the networks sacrifice connectivity for one or a small number of nodes, the connectivity for the remaining nodes may be significantly prolonged.

C Signal Stability Routing

In the signal stability based adaptive (SSA) routing [1], each link is classified 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. A mobile node only processes a route request (RREQ) that is received from a strong link.

III. ROUTING

Routing is the process of selecting paths in a network to forward the data packets. In packet switching networks, routing directs packet forwarding, the transit of logically addressed packets from their source toward their ultimate destination through intermediate nodes; typically hardware devices called routers, bridges, gateways, firewalls, or switches. Most routing algorithms use only one network path at a time, but multipath routing techniques enable the use of multiple alternative paths.

The routing protocol specifies how routers in a network share information with each other and report changes. The routing protocol enables a network to make dynamic adjustments to its conditions, so routing decisions do not have to be predetermined and static. A routing protocol shares this information first among immediate neighbours, and then throughout the network.

A. Node Lifetime Prediction Algorithm

If there are two nodes that have the same residual energy level, an active node that is used in many data-forwarding paths consumes energy more quickly, and thus, it has a shorter lifetime than the remaining inactive node. In lifetime prediction routing evaluate the node lifetime that is based on its current residual energy and its past activity[15]; however, it present a much simpler solution that does not need to calculate the predicted node lifetime from each data packet.

The term *Ei* represents the current residual energy of node *i*, and *evi* is the rate of energy depletion. *Ei* can simply be obtained online from a battery management instrument, and *evi* is the statistical value that is obtained from recent history. An exponentially weighted moving average method to estimate the energy drain rate. At time *t*, we can obtain the estimated node lifetime in figure.2 as follows:

$$T_{N_i} = E_i^{nT} / ev_i^n \,,\ t\ [nT, (n+1)T] \text{---(1)}$$

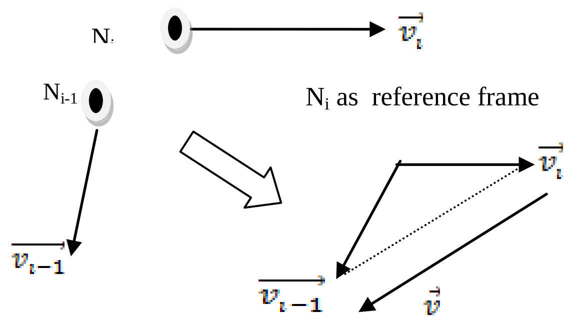

Figure.2 Estimated node lifetime

STEP 1 : Consider that the two nodes have same residual energy.

STEP 2 : Node life time = current residual energy + past activity solution..

STEP 3 : Calculate the predicted node lifetime for each packet.

STEP 4 : Get the E_i value from online battery management instrument $E_i \rightarrow$ current residual energy of node i $ev_i \rightarrow$ Energy drain rate

STEP 5 : Get the ev_i value from recent history .$ev_i \rightarrow$ Statistical value

STEP 6 : By using EWMA method estimate the ev_i.

STEP 7 : For T seconds, node i reads the instaneous residual energy value $E_i^0, E_i^{2T}, E_i^{3T}$ in every period [0,T][T,2T],….

STEP 8 : Estimated energy drain rate ev_i is obtained as

$$\begin{cases} ev_i^0 = 0 & n = 0 \\ ev_i^n = \dfrac{E_i^0 - E_i^T}{T} & n = 1 \\ ev_i^n = \propto \dfrac{E_i^{(n-1)T} - E_i^{nT}}{T} + (1-\propto) ev_i^{n-1}, & n > 1 \end{cases}$$

STEP 9 : Calculate the energy drain rate for nth period ev_i^n and (n-1) period ev_i^{n-1}

STEP 10: $\propto$ denotes the energy drain rate of nth and (n-1)th period .

STEP 11: At time t, the estimated node lifetime is

$$T_{N_i} = \frac{E_i^{nT}}{ev_i^n}, \quad t \in [nT, (n+1)T]$$

Algorithm 1. For Node Lifetime

B. Link Lifetime-Prediction Algorithm

To evaluate LLT using the connection lifetime; however, it is difficult to predict the connection lifetime TCi between two nodes (Ni-1 and Ni) because the nodes in MANETs may move freely. In this algorithm, it handles the connections that are in an unstable state and may only last for a short period particularly, ignoring the stable one for simplicity [2]. The reasons are given as follows, first, it concerned with the minimum node lifetime or the connection lifetime in a route. Since two nodes of a stable connection are within the communication range of each other, the connection lifetime may last longer, and they are not a bottleneck from the route to which they belong .Second, it is easier to model the mobility of nodes in a short period during which unstable connections last. It can assume reasonably and simply that the nodes move at a constant speed toward the same direction in such a short period.

The connection time Tci depends on the relative motion between Ni and Ni-1, and the connection is said to be broken when two nodes (Ni-1 and Ni) are moving out of each other‟s radio transmission range R. Apparently, there are two important issues here. One is how to measure the distance between nodes Ni and Ni-1 while the other is how to compute the relative velocity of these two mobile nodes. It is easy to measure the distance between nodes Ni and Ni-1 when it use Global-Positioning-System-based. Another simple method [1] is to measure the received signal strength. Assuming that senders transmit packets with the same power level, a receiver can measure the received signal power strength when receiving a packet and then calculates the distance by directly applying the radio propagation model. If the received signal power strength is lower than a threshold value, it regards this link as an unstable state and then calculates the connection time

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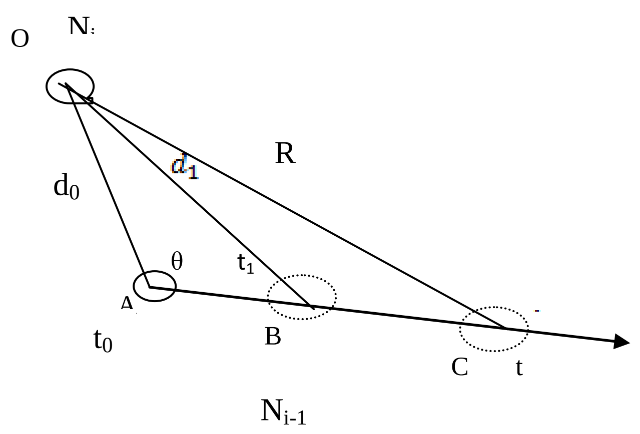

Figure.3 Relative motion of two nodes

Figure 3. Shows 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 we consider node *Ni* as the reference frame, node

N_{i-1} is moving at a relative velocity of v, as given by the following: $v = v_{i-1} - v_i$.

STEP 1 : Consider the relative motion of two nodes (N_{i-1},N_i) moving at relative velocities $\overrightarrow{v_i}$ and $\overrightarrow{v_{i-1}}$ relative to ground at a given time t.

STEP 2 : Consider the ground as a reference frame by default.

STEP 3 : Set node N_i as the reference frame, node N_{i-1} is moving at a relative velocity of $\vec{v}$,

$$\vec{v} = \overrightarrow{v_{i-1}} - \overrightarrow{v_i}$$

STEP 4 : By using LLT prediction algorithm, Set the reference frame in node N_i

STEP 5 : Consider the node N_{i-1} moves at velocity $\vec{v}$ relative to the velocity of node N_i.

STEP 6 : At time t_o and t_1, node N_{i-1} receives two packet from node N_i.

STEP 7: Assume that node N_{i-1} moves out of node N_i's radio transmission range at prediction Time t

STEP 8: At time t_0 node N_{i-1} receives a packet from node N_i and the received signal power is P_0, distance d_0 between the two nodes calculated by using radio propogation model.

STEP 9 : Calculate the d_1 value with a two ray ground model for simulation in NS_2.

STEP 10 : Calculate the unknown parameter (t,v,θ) value by using the lae of cosines

$$d_1^2 = d_0^2 + [v(t_1-t_0)]^2 - 2d_0v(t_1-t_0)\cos\theta$$

STEP 11 : Calculate the area for three triangles ($\Delta OAC, \Delta OAB + \Delta OBC$) $S_{OAC}=S_{OAB}+S_{OBC}$

S→area of the triangle

STEP 12 : Convert the area of the triangle in Heron's formula

$$S=\sqrt{l(l-a)(l-b)(l-c)}$$

a,b,c→ sides of the triangles

where $l=(a+b+c)/2$

STEP 13 : Calculate the parameters (t,v,θ) by using heron's formula

STEP 14 : By solving this two simultaneous equations, the residual connection time T_{c_i} is Calculated $T_{c_i} = t-t_1$

Algorithm.2 for Link Life Time

C. Route Lifetime Prediction Algorithm

A route consists of multiple links in series, it is said to be broken if any single link among its links is broken, and thus, the lifetime of the route becomes the minimum lifetime of all links in this route. A link is composed of the two nodes in a connection and the connection itself, and the LLT includes both the node lifetime and the connection lifetime.

1. A link is formed between two adjacent mobile nodes, which have limited battery energy (N_i) and can roam freely, for calculating nodes energy node lifetime prediction algorithm is used.
2. If link is broken, any of the two nodes is not alive due to exhaustion of energy or if these two nodes move out of each other's communication range.

A link Li consists of a connection C_i and two nodes (N_{i-1},N_i), where C_i represents the connection between nodes N_{i-1} and N_i,and it is maintained until the adjacent nodes (N_{i-1},N_i) move out of each other's communication range under the assumption of no energy problem in both nodes N_{i-1} and N_i.We introduce connection lifetime T_{c_i} to represent the estimated lifetime of the connection C_i, and it only depends on their relative mobility and distance of nodes N_{i-1} and N_i at a given time. The term T_{N_i} denotes the estimated battery lifetime of node N_i. Then, the lifetime of the link L_i is expressed as the minimum value of (T_{c_i},$T_{N_{i-1}}$, T_{N_i}), i.e.,

$$T_{L_i} = \min(T_{C_i}, T_{N_{i-1}}, T_{N_i})$$

IV. SIMULATION SETUP

A. Node Configuration

Node configuration essentially consists of defining the different node characteristics before creating them. They may consist of the type of addressing structure used in the simulation, defining the network components for mobile nodes, turning on or off the trace options at Agent/Router/MAC levels, selecting the type of ad hoc routing protocol for wireless nodes or defining their energy model.

B. Simulation Scenario

The proposed method addresses the congestion issues considering delay, packet loss and routing overhead. In order to evaluate the performance of the multipath video multicasting and to compare it with conventional multicasting, the below parameters are configured in the network simulator.

Parameter	**Range**
Packet Size	2000 bytes
No. of Nodes	108
Protocol Used	AODV
Dimension	1000*1000
Channel Type	Wireless channel IEEE 802.11
Queue Type	Drop Tail/PriQueue
Antenna	Omni Antenna
Protocol	TCP
Mobility	10/s

Table.1 Parameters range for network simulator

C. Throughput

Throughput is the number of useful bits per unit of time forwarded by the network from a certain source address to a certain destination, excluding protocol overhead, and excluding retransmitted data packets illustrated in figure 4.

$$\text{Throughput} = \frac{\text{No of Packets Received}}{\text{Simulation time}}$$

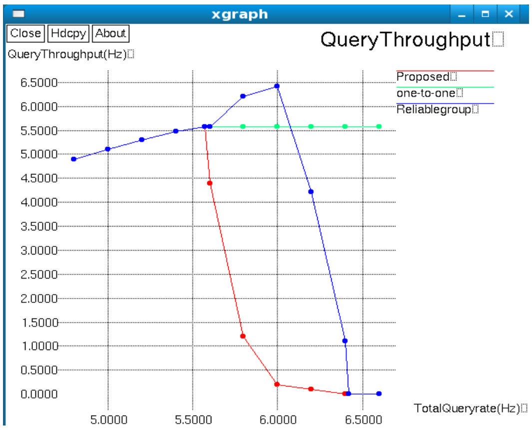

Figure.4 Throughput of data packet

E. Overhead

Routing overhead is define as being the number of routing packets – such as the protocol message- per number of packets successfully received at the destination in figure 5.

$$\text{Overhead} = \frac{\text{No of routing packets}}{\text{No of packets received}}$$

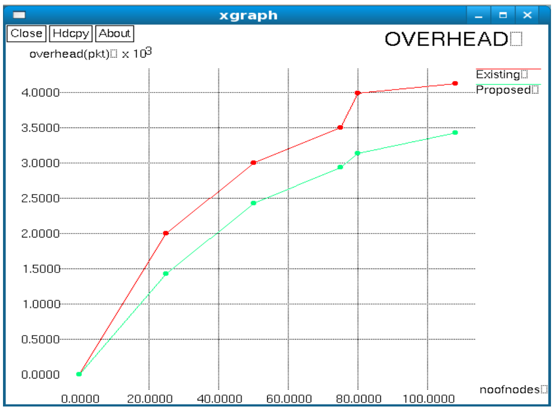

Figure.5 Overhead of data packet

V.CONCLUSION

This paper proposes a lifetime prediction routing in AODV protocol for increasing the data availability. The proposed work in AODV considered both the node lifetime and the LLT to predict the route lifetime and have proposed a route lifetime prediction algorithm that explores the dynamic nature of mobile nodes. The energy drain rate and the relative motion estimation rate of nodes are used to evaluate the node lifetime and the LLT. Combining these two metrics by using proposed route lifetime-prediction algorithm, select the least dynamic route with the longest lifetime for persistent data forwarding that makes the increasing data availability.

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