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SIGNAL STRENGTH AND ENERGY AWARE RELIABLE ROUTE DISCOVERY IN MANET

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Abstract - Frequent changes in network topology and confined battery capacity of the mobile devices are the main challenges for routing in ad-hoc networks. In this paper, we propose a novel, Signal strength and Energy Aware routing protocol (SEA-DSR), which directly incorporates signal strength and residual battery capacity of nodes into route selection through cross layer approach. This model defines a metric called Reliability Factor for route selection among the feasible routes. It is simulated using ns2, under different mobility conditions. The simulation results shows better performance in terms of packet delivery ratio, control overhead and average end-end delay. The proposed model has extended the time to network partition and reduce the path breakages when compared with similar routing protocols DSR and SSA.

Keywords - MANET, reliable routing, link stability, residual energy

I. INTRODUCTION

Mobile ad hoc networks (MANETs) are collections of wireless mobile devices, which can communicate with each other without any infrastructure support. It is a self-configured and self-maintained network with no central authority. Every node in MANET acts as both a host and a router. Dynamic topology, limited bandwidth, battery, CPU resources and multi-hop communication are the characteristics that put special challenges in routing protocol design [1]. In these networks, communication is achieved by forwarding packets along appropriate routes for nodes which are not in the communication range of the source node. These networks can be useful in a variety of applications, such as one-off meeting networks, disaster and military applications, data acquisition in hostile terrain and the entertainment industry.

Several routing protocols have been proposed for MANETs. Based on the route discovery principle, we can classify them into either proactive or reactive. Proactive routing protocols update routes for every pair of nodes at regular intervals irrespective of their requirement. The reactive or on-demand routing protocols [2], determine route only when there is a need to transmit a data packet, using a broadcasting query-reply(RREQ-RREP) procedure. Most of these protocols use min-hop as the route selection metric. It is found that shortest path route has short lifetime, especially in highly dense ad hoc networks even with low mobility, due to edge effect.

They do not address the issue of reducing the path breakage during data transmission.

In most of the on-demand routing algorithms it will take some time to detect the link failure after which, route recovery and maintenance procedures

are initiated. These procedures consumes substantial amount of resources like bandwidth, power, processing capacity at nodes and also introduce extra delay. Selecting routes that endure long time reduce the possibility of route failure and route re-discovery process, which considerably improve the network performance of ad-hoc networks.

Link stability indicates how stable the link is and stability based routing protocols tend to select paths that are long-lived route[3]. Signal strength, pilot signals, relative speed between nodes are the parameters used for the computation of link stability. Lifetime of network is considerably reduced by inefficient consumption of battery. Power-Aware routing ensures that the mean time to node failure is increased significantly[4].

The aim of this work is to propose a novel routing protocol SEA-DSR that considers both the signal strength and remaining battery capacity of the nodes during path selection for reliable data transmission across the network.

It reduce the link failures as well increase the lifetime of Network through the distribution of traffic load.

This paper is organized as follows. In section II, we present related work on power and stability based routing. In section III, we describe the proposed scheme SEA-DSR in detail. Finally, simulation results and conclusions are summarized in section 5 and 6, respectively.

II. RELATED WORK

We first expose relevant research work related to signal strength based routing. Then, we will explicit how our approach combines both the signal strength and energy metrics, to find reliable path for communication and extend the network lifetime.

Most of the routing algorithms proposed for MANET are based on reactive routing strategy, in which route is established only when there is a need to transmit a packet. In these protocols route recovery and maintenance procedures are initiated only after a route break. This procedure consumes extra bandwidth and power at processing nodes and also increases the delay.

It is important to find routes that last longer, to reduce the route breakage and consumption of resources.

In [6], Link stability is defined as a measure of how stable the link is and how long the communication will endure. Signal Strength is one of the parameter used to estimate the stability of links. In [8], the route discovery is based on signal strength and location stability of nodes. In SSA, a mobile node determines the average signal strength at which the packets are exchanged between nodes and location stability is used to choose longer-lived route.

Sulabh Agarwal and Pal Singh propose RABR [9], in which the route selection is done based on the intelligent residual lifetime assessment of the candidate routes. This major challenge with this protocol is, to choose the optimal threshold values. In [10], the authors estimated the link stability based on the signal strength. If the received signal strength is greater than a certain threshold, the link is considered to be stable. In [11], Min-Gu and Sunggu lee proposed a route selection based on Differentiated signal strength [DSS]. DSS indicates whether the nodes are getting closer or getting farther apart. If the signal strength is getting stronger, the link is considered to be stable. If the signal strength is getting weaker in case of node moving away is considered to be unstable link.

In [12], N.Sharma and S.Nandi propose RSQR, in which the link stability and route stability are computed using received signal strength. Based on the threshold values the links are classified as stable or unstable link. Link stability and link uncertainty values are used for stable route selection among all the feasible routes.

Gun Woo and Lee propose EBL [13], in which the authors give importance to both link stability and the residual Battery capacity. The EBL not only improve the energy efficiency but also reduce network partition. Floriano and Guerriero propose LAER [14], in which they consider joint metric of link stability and energy drain rate into route discovery, which results in reduced control overhead and balanced traffic load.

The expected route lifetime is mainly predicted with the parameters node battery energy and link stability. It is preferable to select stable links i.e. links having longer predicted lifetime, instead of selecting weak links which break soon and introduce routing overhead [15].

In [16], Guerriero propose PERRA, an reactive routing protocol, which accounts both link stability and power efficiency. Intermediate nodes in PERRA propogates route request, only if it meet the energy requirement specified by the source node. Thus, the path established is a stable path that incurs residual energy, path stability and estimated energy for data transmission. It also maintain alternate path, which can be used before link break occurs to reduce the path breakage. Control overhead is greatly reduced due to constrained flooding and maintenance of alternate path.

III. SIGNAL STRENGTH AND ENERGY AWARE DSR ROUTING

In this section, we discuss the working procedure of SEA-DSR. The goal of this work is to improve the reliability of route discovery in MANET by using signal strength and energy metrics through cross-layer information sharing. The main features of this protocol is

- Selecting stable routes by accounting signal strength and residual energy level of the intermediate routes.
- Protect against link breakages due to weak link and energy depletion at the intermediate nodes.

The above specified feature ensures that SEA-DSR protocol select routes that endures longer with respect to communication link, where the link with greater signal strength is given preference over the link with weak signal strength and in case of residual energy, where the nodes with greater energy is given preference over the low energy nodes. These results in less path breakage, packet loss, reroute discoveries and routing control overhead. We also go for route maintenance, with the help of signal strength, if it is getting below certain threshold value.

3.1 Route Discovery

When a node needs to send packets to some destination, it search for route in its route cache. It is not possible to maintain the route cache for long duration, as network topology is not consistent. If route to the destination is not available, it starts broadcasting route request packet to its entire neighbor. The RREQ packet of DSR is extended in this protocol. An extra field called reliability count (RELCOUNT) is added to the RREQ packet. This field contains reliability count of the path it comes across. Destination node selects the most reliable route among all the routes based on this value and the hop count value.

3.2 Route Discovery at Intermediate nodes

If an intermediate node receives a RREQ packet from its neighbor, it measures the strength at which it received the packet and energy level of the node. If the signal strength is above the threshold value S_{Thr1} , then reliability count is incremented by HSCNT otherwise it is incremented by MSCNT. If the energy of the receiving is above the threshold value E_{Thr1} (30% battery) then reliability count is incremented by HECNT otherwise it is incremented by MECNT. After this the RREQ packet is broadcasted.

Intermediate nodes are not allowed to reply for the RREQ it received. If node energy is below E_{Thr2} or signal strength is less than S_{Thr2} , the RREQ is dropped.

Algorithm 1 : Implemented in Intermediate nodes

Input: A packet P from neighbor node.

Input: Threshold values S_{Thr1} , E_{Thr1} , E_{Thr2} , signal strength of the packet (SS) and nodeBattery

```

if ( P is a RREQ packet)
  if (NodeBattery < EThr2) Then
    Drop Packet P
    return
  endif
  if ( (RREQ not already forwarded) or
    (RREQ has better RelCount value))
    then
      if (NodeEnergy > EThr1)
        then
          RelCount := Relcount+ HECNT
        else
          RelCount := Relcount+ MECNT
        endif
      if (SS > SThr1) then
        RelCount := Relcount+ HSCNT
      else
        RelCount := Relcount+ MSCNT
      endif
      Broadcast RREQ packet to next hop
    else
      Drop Packet P return
    endif
  endif

```

3.3 Route Selection at Destination Node.

When the destination node receives the first RREQ, it starts the timer Δt for t sec. It stores all the RREQ details in the route cache. After the timer expires, it find the path with maximum reliability factor and send the RREP to it. All the route request that arrives after timer expires, will be dropped.

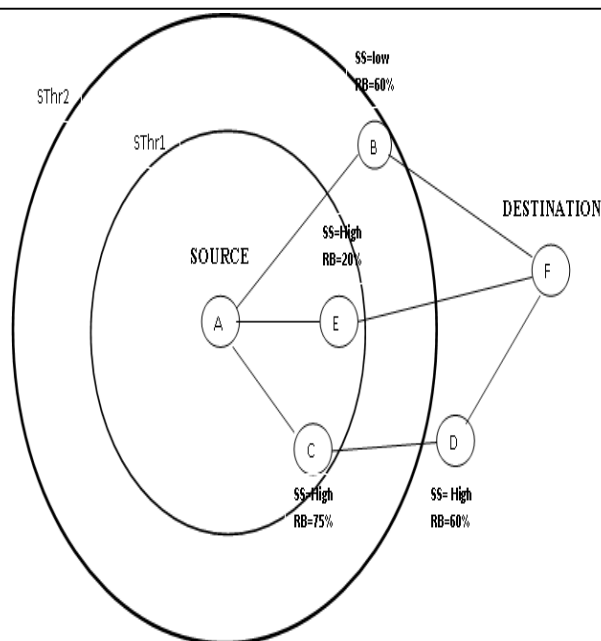


Figure 1. Route Establishment of SEA-DSR

Referring to Figure 1, Node A wants to communicate with Node F, it does not have route to the destination. Node A broadcast RREQ packet to look for the destination. The intermediate nodes “B”, “C”, “D” and “E” on receiving the RREQ packet, updates the reliability count field in it based on the strength of the packet it received and the residual energy of the node. Then it broadcast the RREQ packet to the neighbor nodes.

The destination node “F” on receiving its first RREQ, starts the timer for 1micro sec. After the timer expires, it received RREQ through the following path.

Path I: A – B – F

Path II: A – E – F

Path III: A – C – D – F

The reliability factor for the received path is calculated by the following formula.

$$\text{Reliability Factor} = \frac{\text{Reliability Count}}{\text{No. of Hops}} \quad (1)$$

The path A – C – D – F has the highest reliability count compared with other two path. Hence the RREP is send in that path. Source node A on receiving the RREP packet starts data transmission on that path.

Algorithm 2 To be implemented in Destination Node

Input : A packet P from neighbor node.

Input : Threshold values SThr1, EThr1, EThr2, signal strength of the packet (SS) and nodeBattery

```

If ( P is a RREQ packet)
  If (SS > SThr1) then
    RelCount := Relcount+ HSCNT
  else
    RelCount := Relcount+ MECNT
  endif
  RelFact := RelCount/ hopcount
  Start Timer Δt
  While (not time-out) do
    If (SS > SThr1) then
      RelCount := Relcount+ 0.5
    else
      RelCount := Relcount+ 0.25
    endif
    Make Entry in RouteCache
  end while
  If (N=1) then
    Send a RREP Packet to the source
  else
    Select a route with maximum RelFact value
    Send a RREP Packet to the source
  endif
endif
endif

```

3.4 Route Maintenance

In case, the signal strength of the data packet received falls below SThr2, or the node battery comes below EThr2, the HLP packet is initiated with TTL set to 1, for local recovery. In case Local recovery fails RouteCritical message packet is sent in advance to the source node to avoid path breakage and rediscovery of route is carried on by the source node.

IV. SIMULATION AND EVALUATION

In this section, we investigate the performance of our proposed protocol and it is compared with the closest protocol DSR and SSA. We have simulated it in NS2 simulator. The simulation environment is set as follows.

Parameter name	Value
Topology	1000m × 500m
Number of nodes	50
Mobility model	Random waypoint
Pause time (s)	0
Simulation time (s)	500
Number of flows	10
Traffic type	CBR
Packet size (B)	512
Traffic rate (packets/s)	10
SThr1	$1.5 \times RxThr$,
SThr2	$1.2 \times RxThr$
EThr1	30% of Battery

EThr2

10% of Battery

Simulation Output that has been considered in our simulation are:

Packet Delivery Ratio: It is the ratio of number of packets received at the destinations and the number of data packets sent by the sources. It is a measure of the path discovered by the routing protocol.

Normalized Control Overhead: It is the ratio of control packets sent and the number of a packets delivered at the destinations.

Delay : This gives the average time delay that a data packet has encountered from the time it was sent by a source to the time it was delivered at the destination.

We observe the increase in packet delivery ratio and decrease in end to end delay during transfer of packets from Figure 2 and Figure 3 respectively. We also discover that our SEA-DSR have reduced the number of RREQ being transmitted by the nodes. This is because of the restriction of propagation of control packet over unstable links.

With the formation of more stable routes, active routes are less prone to route breakage and the probability of route breakage and route repair decreases. Hence the number of control packets is reduced up to 10%. This is shown in Figure 2.

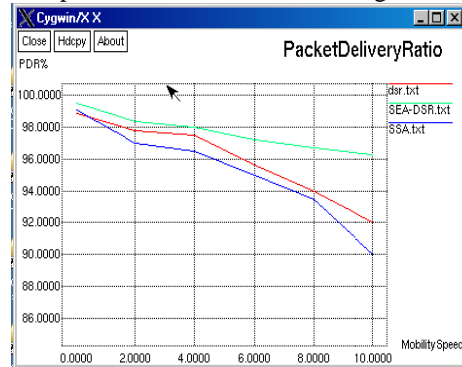


Figure 2. Packet Delivery ratio vs Mobility

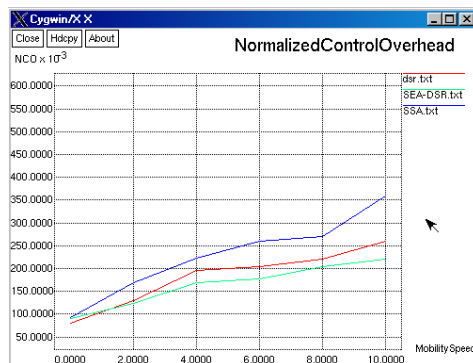


Figure 3. Normalized control overhead vs Mobility

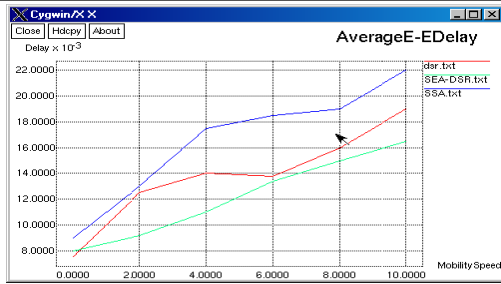


Figure 4. Avg. End-End Delay vs Mobility

Restriction on broadcasting routing packets over unstable links and waiting after first route request for the timer to expire during route discovery lead to slight increase in delay for route establishment. End-End delay in case of low mobility is 3-5% higher compared with DSR protocol, which is shown in Figure 4.

Finally, we evaluated the variance of residual node energy, which is given in the Figure 5. This parameter is a measure of load balancing capability of the protocols. SSA protocol is worst in load balancing capability because it selects nodes in terms signal stability and path history and not considering energy or traffic load of the intermediate nodes.

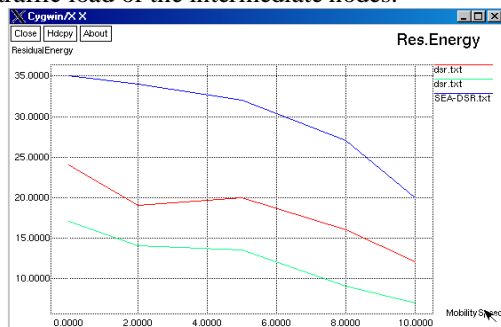


Figure 5. Avg. Residual Energy vs Mobility

SEA-DSR protocol show better performance in which upto 15% decrease in variance of residual energy is achieved, by considering energy as one of the metric for route selection and it extends the time of network partitioning due to energy drain which is shown in Figure 5.

V. CONCLUSION AND FUTURE WORK

This paper presented SEA-DSR, proposed for reliable route discovery and route maintenance in MANET. The proposed routing strategy significantly increase the time to network partition and reduces the path breakage, by balanced energy consumption at the intermediate nodes. Simulation results show that SEA-DSR outperforms SSA and DSR in terms of Packet Delivery Ratio, Control Overhead and delay in highly dynamic environment. In case of low mobility, the proposed model has slightly high delay compared with DSR and SSA. It is observed that the variance in residual battery is reduced greatly.

QoS provisioning for real time traffics and performance under different mobility models are left as part of our future work.

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