International Journal Of Computer Science And Applications Vol. 1, No. 2, August 2008
ISSN 0974-1003

Energy Aware Backbone On Demand Vector Routing for MANET

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ABSTRACT

Mobile Ad-hoc network is a collection of wireless mobile hosts forming a temporary network without the aid of any established infrastructure. The recent trend in ad hoc network routing is the reactive on-demand philosophy where routes are established only when required. Most of the protocols in this category, however, use single shortest route and do not utilize other alternate paths. There are various types of restrictions in MANET. The biggest restrictions are confined to energy of the node and routing. This paper proposes a scheme to improve existing on-demand routing protocols by introducing the concept of energy aware backbone routing. The proposed protocol is an enhancement to the existing Ad hoc On- Demand Distance Vector routing protocol (AODV) that offers considerably good routing services. Backbone routing, which is an alternate form of routing, has gained importance as it can be used to enhance reliability of the network and saves the control overhead, which potentially improves the data rate and the QOS in turn. The proposed protocol utilizes the benefits of both backbones routing as well as the energy aware routing.

Categories and Subject Descriptors

C.2.2[Compute Communication Networks]; Networks Protocols.

General Terms

Design, Algorithms

Keywords

Mobile Ad-hoc Network,, Energy Aware Routing, Energy Aware Backbone Routing-AODV, Backbone Node, Ad-hoc On Demand Distance Vector(AODV)

1 INTRODUCTION

The term MANET stands for Mobile Ad-hoc Network. These networks follow a unique organizational and behavioral logic by operating without any infrastructure. Hence, nodes must collaborate amongst themselves in order to interconnect, organize the topology and establish communication. Some specific applications of MANET are military communications, virtual classrooms, emergency search and rescue operations and communication setup in exhibitions, conferences, meetings, etc.

In MANET, each node acts as both a router and an end node which is a source or destination. Failure of some nodes operation can greatly impede performance of the network and even affect the basic availability of the network, i.e., routing and energy depletion of nodes has been the main threats to the availability of MANET. Since the mobile nodes have limited battery power, it is very important to use energy efficiently in MANET.

Besides the energy limitation there is one more issue to be addressed that is when the number of nodes in a network increases. Considering the nodes as a flat adhoc network will degrade the performance. Other than this many hop paths in large-scale network are prone to break and cause many packet drops. Packet drops can be treated as waste of bandwidth and worsen network performance. All these issues prevent the flat ad hoc network from scaling to large-scale. Thus, a new methodology is needed for building a large scale ad hoc network. An emerging promising solution is to build a physically hierarchical ad hoc network and mobile wireless backbones.

The proposed work is a new approach in MANET through which the network can adopt backbone based routing scheme, just like the fixed networks and can make sure that the nodes participating in the routing be stable and the probability of break-down of the link due to the movement of the nodes and the energy losses be minimized. Hence it would improve the throughput of the network and increase the longevity of the network.

This can also improve the overall lifetime of a path and the regions resulting in less control overhead. It should be noted here that this proposed model does not require the nodes to broadcast hello packet periodically rather only back bones has to generate it to reach to other back bones. Therefore these packets can easily be uni casted. Hence saving the channel from being overloaded with the hello packets. Therefore such a network can handle the congestion better.

The rest of the paper is organized as follows. In section II, AODV routing protocol is reviewed. Section III explains the related work. Section IV explains the methodology of the new routing protocol. Section V explains the simulation. In section VI results are analyzed. Section VII concludes the paper with conclusion and future work.

2 OVERVIEW OF AODV

In this section, we start with a general review of Ad-hoc On-demand Distance Vector (AODV) routing protocol, in MANETs.

In AODV[1]When a source node wants to send a packet to some destination node and does not have a valid route to that destination, it initiates a path discovery process to locate the destination. It broadcasts a RREQ (Route Request) packet to its neighbors, which forward the request to their neighbors, and so on, until the destination is located or an intermediate node with a "fresh enough" route to the destination is located. During the process of forwarding the RREQ, intermediate nodes record in their route tables the address of neighbors from which the RREQ was received, thereby establishing a reverse path. When the RREQ has reached the destination or intermediate node with a "fresh enough" route, the destination/intermediate node responds by unicasting a RREP (route reply) packet back to the neighbor from which it first received the RREQ. As the RREP is routed back along the reverse path, nodes along this path set up forward route entries in their route tables. Finally, the source node can send its packets to the destination via the established path.

3 RELATED WORK

MANET [1] or Ad-hoc network is the cooperative engagement of a collection of mobile nodes without the required intervention of any centralized access point or existing infrastructure. Each Mobile Host operates as a specialized router and routes are obtained as needed i.e. on demand with little or no reliance on periodic advertisements.

As pointed out earlier flat adhoc network suffer from poor scalability. Building a physically hierarchical ad hoc network is a very promising way to achieve good scalability.[6] [9] A design methodology to build a hierarchical large-scale ad hoc network using different types of radio capabilities at different layers. In such a structure, nodes are first dynamically grouped into multihop clusters. Each group elects a cluster-head to be a backbone node (BN). Then higher-level links are established to connect the BNs into a backbone network. Following this method recursively, a multilevel hierarchical network can be established. Three critical issues are addressed in this paper first optimal number of BNs are analyzed for a layer in theory. Then, new stable clustering scheme to deploy the BNs is proposed. Finally LANMAR routing is extended to operate the physical hierarchy efficiently. Significant amount of studies [7][8][10][11] have been done on backbone organization and QOS.

Conservation of power in mobile nodes is of prime importance .Routing protocol have been modified to conserve Energy [2]. An improved ADOV is suggested to extend the entire network life time by adjusting RREQ delay time according to the acquired data from comparison between node energy states and entire networks energy mean value.

[5] Proposed Power management schemes directional local recovery (DLR) and dynamic power management schemes to reduce the power consumption and balance the load among the mobile nodes. The power variance has been as a metric to evaluate the performance of power balancing.

An adaptive routing mechanism [3]is studied based on the energy consumption speed of nodes for on-demand routing protocols in mobile ad-hoc networks. The algorithm allows a fairly low energy consumption during route establishment by building routes that are lower congested than the others.

4 METHODOLOGY

We propose a scheme that enhances AODV protocol by region based routing concept. Here the communication area is divided into regions and each region would have a back bone node. All the routing is carried out through the backbone nodes only. Therefore a centralized control is obtained in MANET.

A. *Energy aware Backbone Routing*

Backbone node is a node with maximum residual energy. Initially every node will transmit a request to become a backbone node to it's neighbors. This request contains the residual energy and the time stamp of the nodes. If some node receives a request before it's request and finds out that it's energy is lesser than the energy of some other packet then it will not transmit the request. Hence a node, which has the smallest time stamp for backbone request and has sufficient energy becomes the backbone. Once a node becomes backbone it notifies the same to all it's neighbors. During the route request, the source node broadcasts the RREQ and the packet is forwarded in the same way like the AODV. During the route reply phase, the destination sends the reply to it's backbone rather than the previous node, along with the entire reverse route information. This backbone will transmit the reply to the backbone of the next node if the next node is not part of the same region. Thus the reply is routed through the backbone. Once a backbone identifies that the destination is in the same region, it sends it to the destination. Thus the path is established through the backbones only. During the communication phase the backbones may become in-eligible to remain as backbone either because of energy loss or if it moves away of the current region boundaries. Under such circumstances, during the route maintenance phase, the neighbors will identify that the backbone of the region is not present. The backbone initialization will be repeated as mentioned above.

If energy loss of the Node is x. Then NE is calculated by

NE=(x-del(e)/del(t)-del(PE)/del(t))-(Energy(control_hello)+energy(data)+Energy(RREQ)

+ Energy (RREP)………… (1)

Where,

NE = Node energy; PE= processing energy;

del(t) is the time under consideration

del(e)/del(t) is the loss of energy with respect to time.

del(processing energy)/del(t)) is the loss of processing energy with respect to time.

Under ideal conditions

NE=(x-del(e)/del(t))- energy(control_hello)…. (2)

If the node decides to switch off for some time to regain some energy

NE=NE+(battery residual energy Recover Be)..(3)

ISSN 0974-1003

Where,

Be=Total Charge/del tau.

Tau is the charge time.

Energy loss / packet=K. distance between two points

Where,

k=directionality constant

Number of packets transmissible in a link=NE(calculated with processing and battery loss)/loss due to transmission …………………….(4)

Where , pack num =number of packets in a link

Route expiry time=number of packets transmissible in a link. NE=Node energy.

Using the energy consideration we will form our backbone network by following ways.

We consider: *N* mobile stations (M_S) to be covered by *M* mobile routers (M_R), all located on a flat rectangular field of surface *A*x*B*.

- each mobile node *MSi* is represented by the geometrical point *Pi* with coordinates *(xi, yi)*,
- each mobile router *MRj* is represented by the geometrical point *Qj* with coordinates *(aj, bj)*.
- *Rr* denotes the mobile router transmission range,
- *Rm* denotes the mobile station transmission range,
- *d(J,K)* denotes the Euclidian distance between geometrical points *J* and *K*.

In order to be covered by a router, the distance between a mobile station and its closest router must be less than *Rm*. Two mobile routers are neighbors (i.e. adjacent in the backbone network) if the distance between them is less than *Rr*.

We define:

$X_{min} = \min_{1<=i<=N}(x_i)$, $x_{max}=\max_{1<=i<=N}(x_i)$

$y_{min}=\min_{1<=i<=N} (y_i)$; $y_{max}= \max_{1<=i<=N} (y_i)$

For *i* =1,...,*N* and *j* =1,...,*M* , *(aj, bj)* denote the router's coordinates,

$$\text{Let } \lambda_{i,j} = \begin{cases} 1 & \text{if } d(p_i,Q_j) <= R_m \\ 0 & \text{otherwise} \end{cases}$$

In other words, $\lambda_{i,j}$= 1 iff the mobile station MS_i is covered by the mobile router MR_j (ensures the connectivity between mobile node MS_i and mobile router MR_j)

For *i, j* =1,...,*M* ,

$$\text{Let } \mu_{i,j} = \begin{cases} 1 & \text{if } d(Qi,Qj) <= Rr \\ 0 & \text{otherwise} \end{cases}$$

$\mu_{i,j}$ =1 iff *MRi* is an adjacent router of *MRj* in the mobile routers' backbone (ensures the connectivity between two mobile routers *MRi* and *MRj*). The backbone network may be represented as a graph whose vertices represent the mobile routers, and whose the adjacency matrix is ($\mu_{i,j}$); 1<= i , j <=M for I=1, … N, Let τ_i=1iff *MSi* is covered by at least one mobile router, that is, if there exists at least one router *MRj* for which $\lambda_{i,j}$=1 To check the backbone (formed by mobile routers) connectivity, we will test whether it is possible to create a route from any mobile router *MRs* (*s=2,…, M*) to the router number 1 (*MR1*) Hence, we define $z^s_{i,j}$ as $z^s_{i,j}$ =1 if the route from the router *s* to the router number 1 goes through the link (i, j), otherwise $z^s_{i,j}$ = 0

B.*Algorithm*

Nomenclature:

Let R1, R2, R3 and R4 be the regions.

X,Y are the co-ordinates of the regions.

Mob[i] represents the mobile structure

Rgn is the region of the mobile

x,y are the coordinates of the mobiles

data is the actual load.

Mobility is probability of movement(0 to 1)

Loss is the data loss during transmission

Delivered is the amount of load successfully reaching the destination.

Process:

```
Set Xmin, Xmax, Ymin, Ymax for all the regions.
for i=0;i<Max;i++
  {
      for j=0;j<tot_rgn;j++
   / Find out which region Mob[i] belongs from
     iff mob[I].x>Xmin[j] && mob[I]<Xmax[j] && mob[I].y >Ymin[j] && mob[I].y>Ymax[j] then
     mob[I].rgn=j;
  }
```

Now the back bones of all the nodes are calculated using the Maximum energy theory.

```
initiate data,mobility
while(data>0)
  {
   Transmit data;
  Move the mobiles;
  Update energy;
  Check the backbone validation.
  If (backbone of a region ineligible)
   {
   re-calculate the backbone.
   Loss++;
   Data--;
```

```
  }
else
{Delivered++;
Data--;
}}
```

Therefore after certain period of time the nodes posses a high probability of being broken. In conventional energy aware routings, instead of a shortest path for the communication, nodes with maximum residual energies are selected for routing. But the problem persists as and when the load increases and the communicating peers also increases, the nodes looses their energy at a rapid rate, causing faster probability of the link failure. Even though such cases can be avoided through route maintenance, it increases the control overhead to a great deal as the route repair is global and distributed. It is assumed that the nodes would regain some energy if they were not to participate in routing for some time (ideal time energy gain). Therefore if the highest energy nodes are selected for routing they can handle maximum load. At the same time, when they find their energy level to be insufficient for routing, they can notify the nodes in the same region, which would change the route without global route repair request. It saves the control overhead, which potentially improves the data rate and the QOS in turn.

5 SIMULATION

Using simulation performance of our EAODV is compared with AODV. We have assumed an area of 100 x 100 meters, which is divided into 2x2, cells each cell having a Backbone. At the beginning we have selected maximum number of mobiles. These mobiles would be placed one in a cell randomly. Each node starts from a random location and moves in any of eight direction E,W,N,S,NE,SE,NW,SW. Once it reaches the boundary it moves in opposition direction. A source and the destination are to be manually selected by the user. Initially all the mobiles would be given some initial energy . As the packets are to be transmitted through the nodes, they would loose some energy. A threshold would be selected to choose a backbone node. From the rest of the nodes in the area, any node would re elected dynamically as the B-Node.A path consisting of backbone nodes is formed.

6 RESULTS AND ANALYSIS

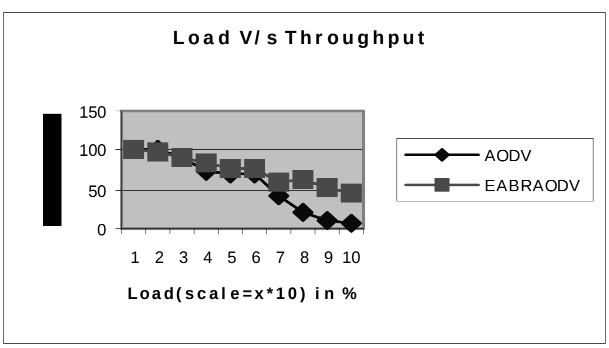

Figure2 the load v/s the Throughput

Graph shows that even when the load is nearly 100% the Throughput is considerably high. This is because of the dynamic backbone management.

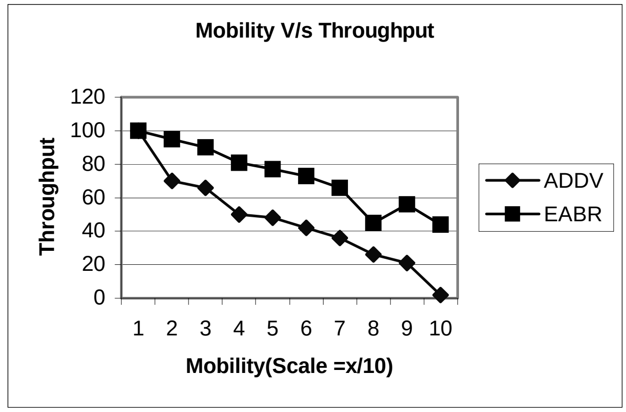

Figure3. Mobility v/s Throughput

Graph shows that as the probability of mobility increases throughput decreases, but it does not fall beyond a level. The throughput degrades because as the mobility increases the backbones are to be re configured fast. Hence the throughput is down. But the proposed method still helps maintaining a decent performance.

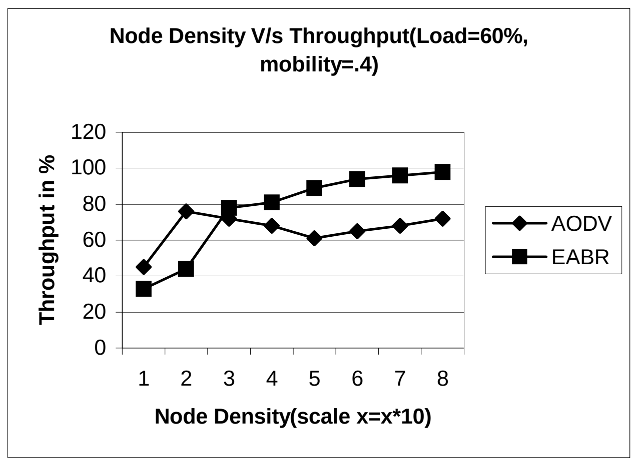

Figure4. The Node density v/s Throughput

Graph shows that the mobile distribution does not have too much affect on the performance. But the performance is best if all the nodes are speeded in a closer area, the possibility of the backbones going afar is remote, hence the throughput is more.

7 CONCLUSION

This paper suggests an improved ADOV with energy aware backbone. Routing traffic is diverted to the backbone node instead of the nodes that form the path to destination. Backbone node is elected based on the highest energy node posses from a set of nodes.The results show throughput is increased however the path involving the backbone may not be shortest path ,thus leading to increased end to end delay. Our focus would be to improve upon increased end to end delay.

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