Energy Efficient DSR Algorithm based on Topology for Mobile Ad-Hoc Network

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ABSTRACT

The nodes in the mobile ad hoc networks use typically autonomous sources of energy that have a limited battery lifetime. It is therefore important to minimize the energy consumption of nodes in the wireless networks. This paper propose a new energy efficient algorithm for the dynamic source routing protocol (DSR) which is based on the network topology precisely the approach of enclosure graph and relay region in which communicating through the relay node is more energy efficient than direct communication. In this topology, the network is strongly connected if each node maintains connections with all the existing nodes in its closure. The proposed method investigates distance between the nodes which is proportional with a transmission power used by a node and with the idle listening energy consumption. Our proposition contributes to preserve energy of mobiles units and ensure their connectivity in the routing process.

General Terms:

Computer Science , Wireless Networks

Keywords:

MANETs, routing algorithm DSR, Energy consumption optimization, topology, enclosure graph

1. INTRODUCTION

Energy conservation is a crucial factor for the network lifetime in wireless ad hoc networks. Several studies have shown that network activity dissipates energy and the WNIC component (A wireless network interface controller) can consume 10%-50% of overall system energy[1]. The emission and reception consume significant energy. All these activities create more power dissipation in mobile ad hoc environments. The emission and reception consume significant energy. All these activities create more power dissipation in mobile ad hoc environments. The energy consumed by a node is based on its activities at different network layers. In order to minimize energy consumption in routing layer, several works choose the path that minimizes the total energy consumption. The attention paid to power aware routing protocols, in research, has led to the accumulation of a lot of efficient approaches. Some power aware routing approaches are mentioned here, specifying their advantages and their drawbacks, in order to focus on an improvement of DSR routing protocol [2].In Minimum Battery Cost Routing (MBCR) algorithm[3] and Min-Max Battery Cost Routing (MMBCR) algorithm[4], a route's lifetime is used as a route selection criterion; thus, the route that conserve power and increase in lifetime of node and network is selected for routing. Minimum Total Transmission Power Routing (MTPR)[4] chooses the path that minimizes the total energy consumption without take into account the node remaining energy. In order to maximize the residual capacity of batteries, the algorithm CMMBCR[5] (Conditional Min-max Battery Capacity Routing) identifies the routes that have a sufficient remaining energy of a battery and then selects the routes with minimum total transmission power. Srinivas and Modiano[6, 7] proposed Minimum energy Node-Disjoint Paths algorithm that optimally solves the minimum energy 2-link disjoint paths problem for unicast, based on the weight of link that is equal to the power transmission using the dissemination property of wireless medium in the case of omni-directional antennas[8]. Srinivas et al.[7] applied a polynomial time algorithm called Source Transmit Power Selection (STPS) for minimum energy k node-disjoint paths problem for unicast that finds a set of paths from the source to the destination where the nodes are disjoined and the overall energy cost is minimal. In addition, Liang et al.[9] proposed two centralized algorithms (BLN edge-disjoint algorithm and BLN node-disjoint algorithm). These algorithms aim to minimize the transmission energy consumption and maximize the network lifetime. Many improvements to existing routing protocols have been proposed to make them energy efficient, based on certain characteristics such as multipath support, quality of service support, mobility support and reliability support [10]. EC-DSR[11] considered two energy-related metrics that have been used to determine energy efficient routing path: stable energy-conserving nodes with high quality links. MEDSR [12] use the low power level during the phase of discovery route and a minimum transmit power for data transmission, based on the collect of power information at each node in discovery process. In EDSR protocol [13], the authors defined a dynamic priority weight to select the minimum efficient routing path using calculation methods to get the spending energy units and the link capacity of each routing.

This present work propose a Power Control Dynamic Source Routing (PCDSR) protocol that minimizes the power consumption and control the level of transmit power. The basic idea of the proposed algorithm is to determine the routes that have a minimum weigh of edges, and select intermediate nodes for communication avoiding using a long, energy-inefficient edge. The rest of this paper is or-

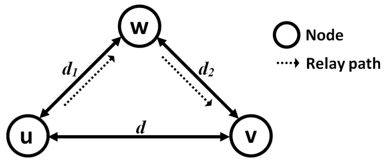

Fig. 1. According to the relative distances between the nodes u, v, and w, the communication using the node w as relay may be more efficient in energy conservation than direct communication from u to v

ganized as follows. Section 2 describes the proposed power aware approach. In section 3, we present the simulation results. The comments and the general conclusions are presented in section 4.

2. PROPOSED PROTOCOL FOR POWER AWARE ROUTING

The protocol DSR employs some optimizations to the basic operation of the route discovery and route maintenance, which can reduce some overhead and improve the efficiency of the used routes. In [2], we have proposed an extension for DSR protocol using an efficient energy technique. This technique is inspired from the approach of Rodoplu et Meng [14] that uses the concepts of relay-region and enclosure graph for the control topology in wireless network . The most inconvenient of the proposed DSR extension is that it needs a high number of coordination for computing the cost of paths when forwarding the request packet and receiving the packets reply. This purpose change the DSR extension algorithm in order to integrate an efficient technique for energy conservation that consumes fewer resources and preserves better the network lifetime. Our algorithm assigned an energy cost to each edge in order to reduce the number of coordination necessary to computing the cost of a minimum energy path during route discovery.

2.1 Relay region

Let's consider an ad hoc wireless network modeled by a graph $G = (V, E)$, with V is the set of nodes and $E \subseteq V^2$ is the set of communication edges, according to the unit disk graph (UDG). Suppose node u must send a packet to node v, which is at distance d (Fig.1). We suppose that the nodes have the same range transmission and the radio signal propagates according to the free space model. So, the power needed to send the message directly from u to v is proportional to d^2. If node w is in region relay of node u, the distance is given: $d^2 \geq d_1^2 + d_2^2$. In this case, the relaying packets through intermediate nodes save energy instead of directly transmitting packets.
The region relay of a pair transmitter-relay of node (u, w) identifies the set of points in the plan for which the communication via the node relay is more efficient in energy conservation than a direct communication [14]. Formally, the region relay is defined

$$RR_{u \to v} = \{(x, y) \in R^2 : P_{u \to w \to (x,y)} < P_{u \to (x,y)}\} \quad (1)$$

where
$P_{u \to (x,y)}$: transmit power from node u to node v.
$P_{u \to w \to (x,y)}$:transmit power from node$u$ to node v using the intermediate node w to relay u's packet.
The closure of node u is defined as the union of the complement of relay regions of all nodes that the node u can achieve, by using its maximum transmit power.

2.2 Energy consumption model

We assume that the node u wants to send a message to node v , in case of direct transmission, the minimum power required to send the message is written as follows

$$P_{u \to v} = \tau d_{u,v}^{\alpha} \quad (2)$$

Where
$\tau d_{u,v}^{\alpha}$ is the energy transmission from node u to node v ,α is the path loss exponent,$2 \leq \alpha \leq 4$, it depends on the characteristics of communication medium [15].
If the node w is used as a relay, the total transmit power is given

$$P_{u \to w \to v} = P_{u \to w} + P_{w \to v} + c \quad (3)$$

Where
c: is a constant term that accounts for the receiver power consumed at the relay node w.
An energy pattern is invoked to calculate periodically the energy value for each selected node. Remaining energy consumption of a node u after time t is calculated using equation

$$E_u(t) = E_u(current) - [P_{tx} + C_{rx} + I_{idle}] \quad (4)$$

Where
$E_u(current)$: is the present energy of the battery.
P_{tx}: is the total energy consumed for transmitted packet at node u.
C_{rx}: is the total energy consumed for received packet at node u.
I_{idle}: This term represents the energy total consumed by each node when the wireless channel is idle. The energy consumed during listening on the control channel depends on distance between the nodes.

2.3 Energy Aware Route Discovery Process

The PCDSR routing algorithm aims to minimize the power consumption during the route construction phase and routing process. The route request packet structure of DSR protocol has been modified to carry information of power level and it is updated periodically. The energy model takes into account the energy consumed for transmitted and received packets and in the idle phase. Initially all nodes have the same initial energy. The main steps of the proposed algorithm is presented: PCDSR is the mechanism in which a node compute its relay region in order to route data through intermediaries nodes instead of using a long energy-inefficient edge, that allow to identifying a minimal transmit power, and then a node can send each packet with the minimum possible transmit power to detect neighboring nodes, in consequence the algorithm associate each link with the suitable weight . After receiving route reply, the process calculates the sum of the links costs of the discovered paths. For transmitting data, the source node records the routes just discovered in the route cache and start sending data packet using minimum energy cost path.

3. SIMULATION RESULTS

For simulations, NS-2 (Network Simulator) is used [16]. The following scenario for the study of the energy consumption is fixed: nodes number= 20 nodes, the area of simulation is $1000mx1000m$, simulation was performed for a duration of $1000seconds$. The mobility model used is the Random Walk Mobility Model. The used propagation model is Two ray ground model. Figure 2 illustrates the evolution of the total energy in time using the DSR and PCDSR. In figure 2, we calculate the network life time of the network by DSR is 992 second while the network

Algorithm 1: Power Control Dynamic Source Routing algorithm

1. Initialization:
$N(u) = \emptyset$ is the neighbor set of node u
N: total number of nodes
d: destination node.
$\gamma(t)$: A threshold of remaining battery capacity at time t.
2. Forwarding the request packet:
A source node s forwards a Request packet
for *each node $u \neq d$ that have received Request packet* **do**
  Update $N(u)$
  Update routing Table
  Update the weight field in the request packet $weight(k, u)$
  let $k \in N(u)$
  Compute remaining power $E_u(t)$
  $E_u(t) = E_u(current) - [P_{k,u} + C_{k,u} + I_{idle}]$
  $E_u(current) = E_u(t)$
  if *$(E_u(t) > thresholdvalue)$* **then**
    RelayRegion(u)
    if *($\exists((k-u)$ and $(k-f-u)$ in header of request packet) and $(P_{k\to f\to u} < P_{k\to u})$* **then**
      Node u ignore request packet with $(k-u)$ path
      u update its routing table and save $(k-f-u)$ path.
    Node u send a Request packet at minimum power $Pmin_u$
    Compute the minimum weight of link :
    $weight(u, u_{i+1}) = E_u(current) - Pmin_u$
3. Receive reply packet:
for *each path ρ_i* **do**
  for *each node u to destination node d* **do**
    Send reply packet
    Compute the path power Cost:
    $Costpath_\rho = \sum_{i=0}^{h} weight(u_i, u_{i+1})$
Select the minimum path:
$R = min(Costpath_\rho)$
End

life time by PCDSR is 1000 sec. We note that the total energy of the DSR network and PCDSR network decreases almost with the same amount on the interval [0-992] seconds. Then, we note stabilization in the level of the total energy of the network DSR, on the interval [992-1000] seconds, because of the loss of network connectivity. In effect, at t = 992 the number of nodes living the DSR network is 6 nodes, and these 6 nodes don't probably communicate because of the remoteness. On the same interval, the energy of the PCDSR network continues to decrease, which means that the nodes continue to communicate.
In conclusion, the provided approach of construction of the paths ensure that the lifetime of routing paths is prolonged, and the route chosen among the multiple paths is the one that provides a minimum total transmission power. From figure 3, it is observed that PCDSR protocol outperforms the DSR protocol in terms of received packets. In PCDSR approaches, the routing offers more resources and reducing the time and the rate of packet loss. This improvement is linked to the fact that the routes contain nodes that maintain connections with all existing nodes in their closure are chosen.

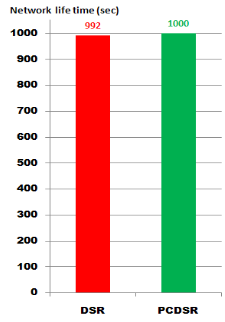

Fig. 2. Network lifetime

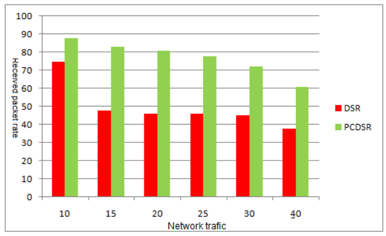

Fig. 3. Rate of received packets in DSR vs PCDSR

4. CONCLUSIONS

In this work, we focus attention on the energy consumption for DSR routing protocol. The proposed PCDSR approach considers the connectivity of links along a route for reliable communication. The integration of the relay region and enclosure graph in DSR algorithm allows choosing the routing paths in such a way that the network is connected, and the energy-cost of the network is minimized.

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