Hop Count Based Energy Saving Dynamic Source Routing Protocol for Ad Hoc Network

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Abstract. Energy conservation has become one of the challenging issues for increasing the life time of Mobile Ad hoc Network (MANET). Several energy saving protocols have been proposed to maximize the life span and one such protocol is Energy Saving Dynamic Source Routing (ESDSR) protocol. ESDSR focuses only on energy and does not consider delay caused due to increase in hop count. This paper Hop Count based ESDSR (HCESDSR) protocol proposes a novel approach to maximize the life span of MANET and to reduce the energy consumption. This reduces the delay caused in ESDSR by considering energy as well as hop count. The number of dead node formation is less in proposed work and hence increases the life of network. The route selection is based on number of hops and energy level of that route. The protocol is simulated using network simulator NS2. The simulation results show that this approach attains energy efficiency of ESDSR and overcomes the limitations of ESDSR.

Keywords: Energy saving, hop count, ad hoc network and routing.

1 Introduction

Ad hoc wireless networks are comparatively new paradigm in multi-hop wireless networking that is increasingly becoming popular and will become an essential part of the computing environment. Today most of the ad hoc mobile devises operate on batteries and one of the major reasons for node failure is battery exhaustion. Therefore, life time of mobile nodes can be maximized by reducing the energy consumption of a node while transmitting packet. Conditional Max-Min Battery Capacity Routing (CMMBCR) [7] protocol chooses the route with minimum total transmission power among routes that have nodes with sufficient remaining battery capacity. The Maximum Residual Packet Capacity battery cost routing (MRPC) [3] protocol shows that power aware routing should depend not only on residual battery but also on link specific parameters such as expected energy spent in reliably forwarding packet over a specific link, channel characteristics of the link, etc.

In Adaptive Energy Efficient and Reliable Gossip (AEERG) routing protocol for mobile ad hoc networks [6], energy efficiency and reliability is achieved by using a

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counter which represent the current number of neighbors at each node that are kept in active state. In LEAR protocol [10] an intermediate node forwards route request message only if its residual battery energy is higher than threshold value, otherwise it will drop the message. The smallest Common Power (COMPOW) protocol [5] selects the smallest transmit power level, which is just enough to maintain connectivity of the entire network. The energy conservation in MANET can be achieved by approaches like transmit power control and load distribution approach.

The transmit power control approach minimizes total transmission energy required to deliver data packet from source to destination. The disadvantage of this approach is that it always chooses the same least transmission power path, which causes this path to be overused and hence 'die' faster than other paths. The load sharing approach focuses on balancing energy usage among nodes by avoiding over-utilized nodes. ESDSR overcomes the limitations of these two approaches [4].

In ESDSR, the nodes which has a 'tendency' to 'die out' very soon are avoided during route discovery phase. The 'tendency' of the node to 'die out' is expresses quantitatively as the ratio of remaining battery energy and current transmit power of the node that is 'expected life' of the node. Once routing decision is made, link by link transmit power adjustment is accomplished depending on the signal strength at which a node receives a packet. But this approach does not consider number of hops needed for transmission and hence delay is higher in ESDSR. This paper focuses on a mechanism in which the path which has a minimum hop as well as energy efficient is selected for transmission. The following section includes the basic function of DSR, ESDSR, the proposed system, its simulation results and conclusion.

2 Dynamic Source Routing Protocol

DSR is based on the concept of source routing [1]. In source routing each packet carries the complete ordered list of nodes in which the packet should pass through the network. This is done by maintaining a cache with route from source to destination. The DSR protocol allows the nodes to dynamically discover a source route across multiple network hops to any destination in the ad hoc network. Each data packet sent then carries in its header the complete, ordered list of nodes through which the packet must pass, allowing packet routing to be trivially loop-free and avoiding the need for up-to-date routing information in the intermediate nodes through which the packet is forwarded. By including this source route in the header of each packet, other nodes forwarding or overhearing any of these packets may also easily cache this routing information for future use.

3 Energy Saving Dynamic Source Routing Protocol

There are many energy aware routing protocols available. In Adaptive Energy-Aware Routing Protocols for Wireless Ad Hoc Networks [1], the idea is to adaptively select the subset of nodes required to participate in the process of searching for a low-power path for networks where in nodes can adaptively adjust their transmission power [3]. In efficient energy management for mobile ad hoc network [8], overhead reduction and energy management technique is adopted for basic DSR protocol. The Energy Saving Dynamic Source Routing (ESDSR) protocol is an enhancement of DSR protocol. The routing decision is made in ESDSR is based on the ratio of remaining energy of the node to the transmitting power.

On Route Reply (RREP), this protocol estimates its expected life using (E_i/P_{ti}). Nodes replace the value recorded in the route reply if the calculated value is less than the recorded value. It repeats the same process for other Route Reply from other routes so that the reply packet carries the value of 'minimum expected life'. The source then selects the path which has higher 'minimum expected life' instead of choosing the shortest path as in case of DSR. After establishing the path for data transmission, link by link power adjustment has to be done based on the transmit power control approach.

This protocol focuses only on the energy and not on hop count. Since packets are not sent through minimum hop, the average number of hop will increase and thereby increases the delay. Proposed system takes both hop count and energy into consideration so that it overcomes the delay in ESDSR.

4 Proposed Work

Proposed System is based on Energy Saving Dynamic Source Routing Protocol. It includes two phases: Route discovery and Route Maintenance [2]. Route Discovery is the mechanism in which the node wishing to send a packet obtains a source route to destination. Route discovery is based on flooding the network with a Route Request (RREQ) packet. The RREQ packet format is

Sender Address	Target Address	Request Id	Route Record

The Sender Address is the source address from where packet is sent, Target address is the destination address to which the packet is sent, Request Id is the unique Id for the corresponding request and route record includes the address of each intermediate node through which RREQ is forwarded. Each and every node maintains a route cache. The pseudo code for route discovery phase is presented in Fig. 1.

Route Maintenance is the mechanism whereby sender is able to detect, if there is any change in the network topology so that it can no longer use its route to destination. Route maintenance is needed for two reasons: Mobility and Energy depletion. Due to mobility, connections between some nodes on the path may be depleting too quickly. The pseudo code for route maintenance phase is explained in Fig. 2.

```
If (no route in sender_routecache)
    Call route_discovery
Else
   Sender broadcast RREQ
If (Current RREQ request id is in neighbors_routecache)
    Discard RREQ packet
Else if (Neighbors address equals Target Address)
    Return RREP
Else
    Appends neighbors_id to route record
    Rebroadcast RREQ
```

Fig. 1. Pseudo code for route discovery phase

```
Sender sends packet to neighbor and waits for acknowledgement.
If (no acknowledgement)
   Link is broken,
   RERR(Route Error) is sent to source;
  Source node erases the route from route_cache;
  Call route discovery
Else
  Process of transmitting packet continues
```

Fig. 2. Pseudo code for route maintenance phase

Proposed system varies in load distribution approach. During the route reply, the source node will record the 'minimum expected life' ($R_j(t)$). But instead of selecting the path with the maximum of the 'minimum expected life', this approach selects the path R which has cost function maximized as follows:

$$C(R,t) = \max(R_j(t) / h_j(t)) \quad (1)$$

where $R_j(t)$ is the path that has the highest minimum expected life and $h_j(t)$ is the number of hops available in the path j. The minimum expected life is computed using the energy metric. The energy metric of a node is the ratio of remaining energy to its transmit power.

$$\text{Energy metric of node } i = E_i / P_{ti} \quad (2)$$

where E_i is the remaining energy of node i on the discovered path and P_{ti} is the transmit power of node i on the discovered path. Thus this approach is energy efficient and overcomes the drawbacks of ESDSR and it is energy efficient than DSR protocol.

In transmit power control approach, when a node receives RREQ packet at P_{recv} which was transmitted at P_{trans}, it calculates transmit power P_{new} for this receiving node such that this node can communicate with the sender by using this minimum required power.

$$P_{new} = P_{min} \quad (3)$$

Where

$$P_{min} = P_{trans} - P_{recv} + P_{threshold} + P_{margin} \quad (4)$$

Where $P_{threshold}$ is the required threshold power of the receiving node for successful reception of the packet and P_{margin} is the power included to overcome the problem of unstable links due to channel fluctuations. Since this protocol maintains a small margin it can save more energy than the protocol mentioned in [7].

Every node maintains a power table which records number of other routes through that node and minimum required transmit power for the next hop in the corresponding route. The power table includes power record and minimum transmit power.

The node records the newly calculated transmit power in ACK packet and sends it. The transmitting node, after receiving the ACK packet reads P_{new} and stores it in a power table. The node uses the transmit power stored in the table to send next data packet. This means that the packet is transmitted only with required power, reducing the energy consumption at each node and thus increases lifetime of the route. When a node wants to send a packet to next hop it will search its own power table, if it finds an entry then sender will transmit at the default power level.

5 Simulation

The simulation is done using NS2 wireless extension. The DSR version with flow state disabled is used. Since the receiving power is constant for each and every node, it is set to zero. The Medium Access Control (MAC) was based on IEEE 802.11 with 2 megabits per second raw capacity. The 802.11 Distributed Coordination Function (DCF) used RTS and CTS control packets for unicast data transmission. The data transmission was followed by acknowledge (ACK) packet. The radio propagation model chosen was two-ray path loss model. The traffic sources were CBR with 512 bytes/packet. The power table is added to basic node structure. Packet header module was modified to carry transmit power level and threshold power level of node. Route cache was modified to store the expected life of nodes for path. A scenario of having 50 mobile nodes as constant and varied the simulation area and transmission range.

The performance metric used to compare the performance of proposed work with DSR and ESDSR are capacity, energy consumption per packet, hop count and number of dead node formation. The capacity is measured as the total number of packets reached the destination. The number of packets that has reached the destination in HCESDSR is more than ESDSR and DSR as illustrated in Table. 1. The energy consumption per packet is less in HCESDSR than ESDSR and DSR and this metric is illustrated in Fig. 3.

Table 1. Total Packets reached destination

Area(sq meters)	HCESDSR	ESDSR	DSR
40000	10920	10857	9340
90000	10174	10112	9145
160000	10282	10239	9024
250000	9600	9500	8132

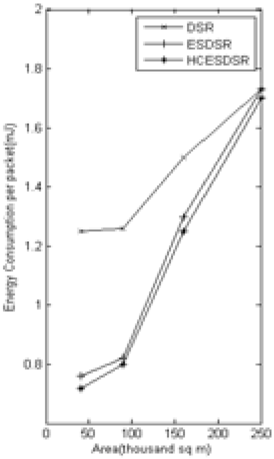

Fig. 3. Energy Consumption per packet

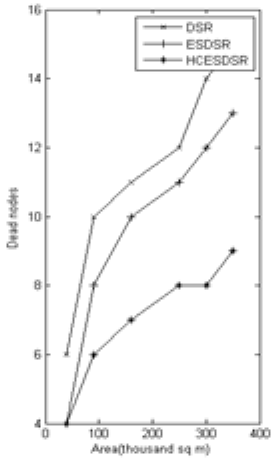

Fig. 4. Number of Dead Nodes

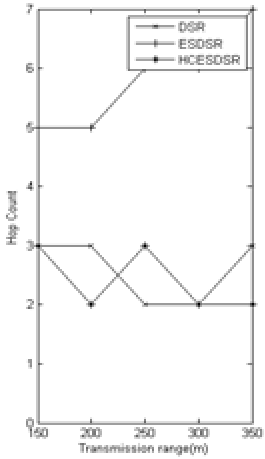

Fig. 5. Number of Hop Count

The transmission range of the node is varied and simulation runs for 50 nodes. The nodes. The network lifetime can be predicted based on the number of dead node formation. The dead node is a node whose energy is completely depleted. When the simulation area is low, the number of dead nodes is less, but high when area increases and this is shown in Fig. 4. The average number of hop counts between a particular source and destination is given in Fig. 5. The delay in transmitting the packet is reduced in proposed system when compared to ESDSR.

6 Conclusion

In this paper, an efficient mechanism for increasing the life time of MANET is proposed. The HCESDSR protocol reduces the delay caused due to hop count. The energy is conserved and can be improved in future enhancement. Here, the number of dead nodes is directly proportional to the transmission area and this will be overcome in the future enhancement.

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