Network Capacity Improvement through Efficient Data Delivery in Mobile Ad-Hoc Networks

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Abstract— Mobile Ad Hoc networks are being increasingly used in wireless communication with many technological enhancements. One of the major issues in such an infrastructure less network is the delivery of the data packets in an energy efficient manner, taking into account the highly dynamic topology of the network. Many of the existing protocols are susceptible to node mobility and one of the major design issues in such networks is the energy efficiency of the resource constrained network. An energy Efficient Routing protocol is proposed in this paper, with the major objective of minimizing the energy consumption of the route. The intermediate nodes act as a forwarding candidate, when they are capable of relaying the packet with the least energy consumption. A sleep/power down approach is also implemented, with an objective of reducing the inactive energy consumption of the nodes not involved in active relaying. Using simulation, the proposed methodology is compared with one of the most dominant routing protocols in wireless networks and is found to achieve better energy efficiency and improved network capacity by using power control in a highly dynamic network.

Keywords- Mobile Ad Hoc networks, Energy Efficiency, Routing Protocol.

I. INTRODUCTION

Mobile ad hoc network (MANET) is an infrastructure-less multihop network where each node communicates with other nodes directly or indirectly through intermediate nodes. Since MANETs are infrastructure-less, self-organizing, rapidly deployable wireless networks, they are highly suitable for applications involving special outdoor events, communications in regions with no wireless infrastructure, emergencies and natural disasters, and military operations.

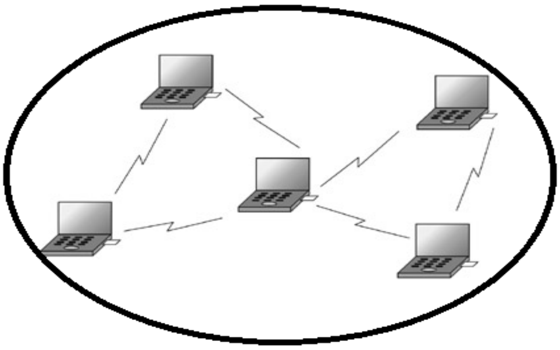

Figure.1 Mobile Ad-Hoc Network.

All nodes in a MANET act as mobile routers participating in decisions required for deciding and maintaining the routes. Routing is one of the important design issues in MANETs due to the highly dynamic and distributed nature of the network. In particular, energy efficient routing is one of the most important design criteria for MANETs since mobile nodes are powered by batteries with limited capacity. Such a resource constrained environment not only affects the node itself but also its ability to forward packets on behalf of others and thus has an adverse effect on the overall network lifetime. Due to these reasons, extensive research is being carried out for developing energy aware routing protocols.

A mobile node consumes energy not only when it is actively involved in transmitting or receiving packets, but also in its idle state, during which it listens to the wireless channel for any possible communication requests from other nodes. Energy efficient routing protocols aim to minimize either the power used for active communication to transmit and receive data packets or the energy consumed during inactive periods.

II. RELATED WORKS

A mobile ad hoc network is a highly mobile, multi hop infrastructure less network and is characterized by dynamic changes in topology due to the mobility of the nodes and a resource constrained network in terms of power and bandwidth. In such networks, the design of an efficient routing protocol becomes critically important.

On-demand routing protocols , which are topology-based (e.g., AODV[1] have been developed with the aim of reducing the control overhead. The proactive protocols (eg.,DSDV[2]) maintain all the routes irrespective of their usage.

IEEE 802.11 uses maximum transmission power [3] to reach the destination node, irrespective of the distance between the source and destination. This is highly energy inefficient, since a lower transmission power could be sufficient to each a nearby neighbour. Ad hoc networks do not have a centralised control and the individual nodes are resource constrained in terms of power and bandwidth. The transmission power of the node determines the connectivity of the network, and the transmission power is computed based on the interference in the network and the distance between the communicating nodes. Power conserving schemes therefore become very crucial in improving the capacity of the network and life time of the node. Various research works are available which try to achieve these metrics by different power conserving schemes.

Power conservation maybe achieved by choosing an optimal transmission power. In [4], the authors proposed a per frame transmission control protocol which improves the throughput by choosing optimal transmit power based on interference and data payload. In [5], the authors use a Conservative CTS Reply as a means of improving the throughput of the network, but did not solve the interference problem. MiSer [6] improves the throughput while considering the interference from the nearby nodes but assumes that the interference will occur only in the receiver side. In [7], the authors propose a power control protocol that achieves improvement in traffic carrying capacity of a homogenous network by reducing the contention among the nodes. In [8], the authors have considered the interference range and use an optimum power to transmit data instead of the exact power.

Power management schemes also try to achieve energy conservation by putting the inactive nodes not involved communication into idle mode which consumes less battery power. [9]

The transmission power control maybe implemented either by minimizing the total energy consumption or by reducing the energy consumed in the inactive state. In [10] the power control is implemented by the former strategy and the latter is utilized in [11].

Geographic routing [12] forwards the data packets in a hop-by-hop fashion using local information. It utilizes the greedy forwarding technique in which the next hop to be selected as the forwarding node is the one which has the largest positive progress towards the destination node. Opportunistic routing is demonstrated in [12] which uses link-state information for the selection of forwarding nodes.

The remaining part of the paper is organized as follows. In Section III, the proposed algorithm is described. In section IV, the various performance evaluation metrics considered in the simulation environment are described. In Section V, the results of the simulation are discussed and the conclusions are presented in Section VI.

III. PROPOSED SCHEME

Mobile Ad hoc network is a non-centralised, self-configuring network. The nodes movement in a random fashion leads to a dynamic topology, that requires that intermediate nodes act as relay nodes, when the final destination is not within the communication range.

The system's robustness can be improved by providing a certain degree of redundancy, which is a measure of availability of an alternate path in case of a path failure. The routing protocols make use of either end-to-end redundancy or hop-by-hop redundancy. Multipath routing establishes end-to-end multiple paths between the source and destination. But the latter category takes advantage of the broadcast wireless medium and transmits the packets co-operatively.

An Ad-Hoc network is resource constrained, in terms of bandwidth and power.

The limited battery power is to be used efficiently since the energy depletion reduces the lifetime of the nodes and may lead to frequent path breaks. Reducing the node or path failure may increase the network life time.

A novel Energy Efficient Routing Protocol (EERP) is proposed, in which several forwarding nodes are chosen based on their energy efficiency. If a selected node is unable to forward the packet, then sub-optimal forwarding nodes will take care of the packet delivery. In this approach, there is always a forwarding node with sufficient energy to forward the packet and therefore there will not be break in the data transmission path. The potential multipaths are computed on a per-packet basis, leading to good robustness of the protocol.

The proposed route selection scheme increases the battery life time of the nodes by using optimal level transmission power for each hop. This helps in reducing the interference range and thereby improves the networks traffic handling capacity. By using minimally required level of transmission power for each hop, proposed route search scheme can increase battery life of the nodes, and also increase network capacity by reducing interference range. The proposed routing mechanism can be deployed without complex modification to the MAC protocol and achieves multiple receptions without losing the benefit of collision avoidance provided by 802.11.

One of the critical issues in the design of the protocol is the selection of the forwarding node. The following algorithm describes the procedure employed for the selection and prioritization of the forwarding nodes:

1. The forwarding area is chosen to be half of the transmission radius of the wireless node.

2. The node should be located in the forwarding area can be chosen as forwarding node and is called as potential candidate list.

3. Check the list for destination node (DN):

4. If DN is in List, then next hop is the destination node.

5. If DN is not in list, find the neighboring nodes in the forwarding area.

6. Assign index values to the nodes based on the minimum distance from source node and available energy level.

7. Highest priority is assigned to the node at the minimal distance and highest energy level.

8. The nodes are included in the candidate list.

9. For packet transmission, choose the node with highest priority and put all other neighbour nodes to sleep state.

When a source needs to transmit a packet, a route request (RREQ) is broadcasted to all the neighbouring nodes, to get the location of the final destination. After collecting the local information, the source attaches it to the packet header. Due to path breaks, there is a possibility of the packet getting dropped and the multi hop path may deviate from the actual destination.

At each intermediate hop, the node that receives the packet checks its neighbour list to determine if the destination is within its transmission range. In that case, the packet will be directly delivered to the destination. This neighbor list is updated using candidate selection algorithm.

After the selection of forwarding nodes, the data transmission is initiated by the source. MANET has limited resources in terms of bandwidth and energy. Low residual energy of a mobile node not only affects the node itself but also its ability to forward packets on behalf of others and thus adversely affects the overall network lifetime. Taking into account these issues, the proposed methodology assigns a threshold value for each node in network based on TTL (time to live) for data transmission. The energy level of each node in the neighbor list is constantly monitored. When the energy level of the node falls below a threshold, it is put in the sleep mode and is not utilized for forwarding of the packets.

The algorithm in brief is given below:

Step 1: Checking ListN for ND

If ND found in ListN then

next hop← ND

Step2: Calculating the distance from ND

For all NI

ListD ← dist(NI, ND)

Step3: Sorting ListD

next hop ← NI corresponding to ListD[0]

Step4: Selection of forwarding nodes

If dist(listN[i],listN[0]) < R/ 2 then

Node N[i] is added to the ListC

Step5: Minimising inactive energy consumption

Select the optimal nodes

if a node N is not in ListC then

nodeN can be in sleep state

else nodeN listens the transmission

Step6: Decrement the Threshold Value

on every successful transmission

decrement the Threshold value

else retain the threshold value

Step7: Recycling Process

if Energy[NI]< critical value

NI goes to sleep state

else Threshold is reset

transmission takes place until Energy[NI] < critical value

new set nodes are selected

IV. SIMULATION ENVIRONMENT

A simulation model based on NS 2.39[13] is used for evaluation. The Distributed Coordination function (DCF) of IEEE 802.11 is used as the MAC layer protocol. The 802.11 DCF has a Request-To-Send(RTS) and Clear-To-Send(CTS) as control packets and this exchange of control packets is prior to the transmission of data packets. Acknowledgements are sent for successfully transmitted data packets. The radio model used here is the Proxim Orinoco PC card by the Lucent technology,[14] compatible with the popular IEEE 802.11b wireless MAC standard and supports a variety of data rates of 1, 2, 5.5 and 11 Mbps. It operates in the same 2.4GHz band and its channel bandwidth is 22MHz as in IEEE 802.11b

The traffic sources used are continuous bit-rate and the data packets are 512 bytes long. The source-destination pairs are randomly chosen. The mobility model uses the random waypoint model in a rectangular field of 1000 x 1000m with varying node density.

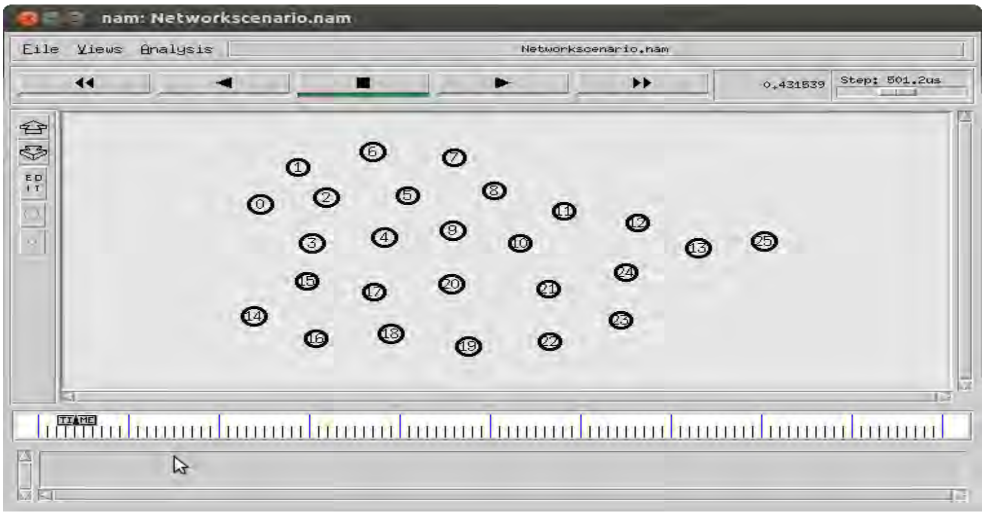

Figure .2.Network Scenario

V. SIMULATION RESULTS

The performance metrics,used as a measure of the Quality of Service achieved during the transmission of the packets and evaluated in the simulation are:

Packet Delivery Ratio:

The packet delivery ratio maybe defined as the number of packets sent from the application layer of the source nodes and the actual number of packets received at the destination nodes.

This is an important evaluation metric as it shows the loss in the transmission.

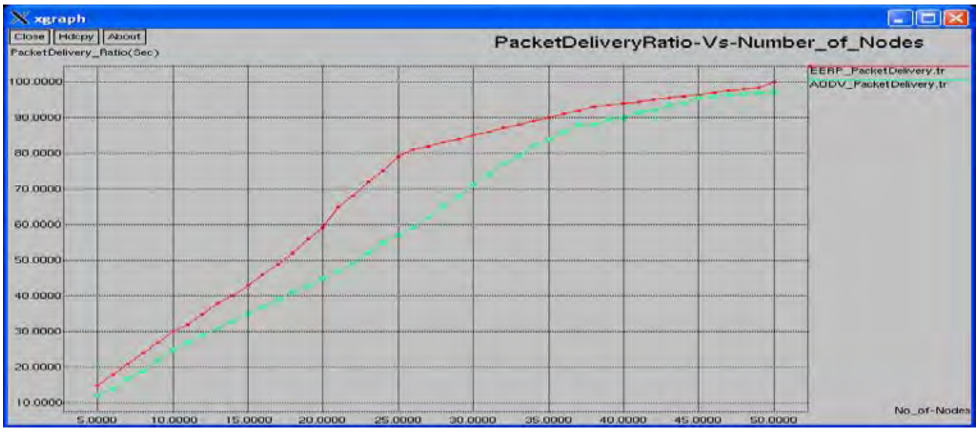

Figure 3. Plot of Packet Delivery Ratio Vs Node Density

It shows how the packet delivery ratio is affected with the number of mobile nodes acting as intermediate forwarding candidates.

When the number of intermediate forwarding candidates is increased ,it is observed that EERP achieves better packet delivery ratio than AODV by 8 %.

Average Throughput:

The average throughput is a measure of the effectiveness of the network in delivering data packets.

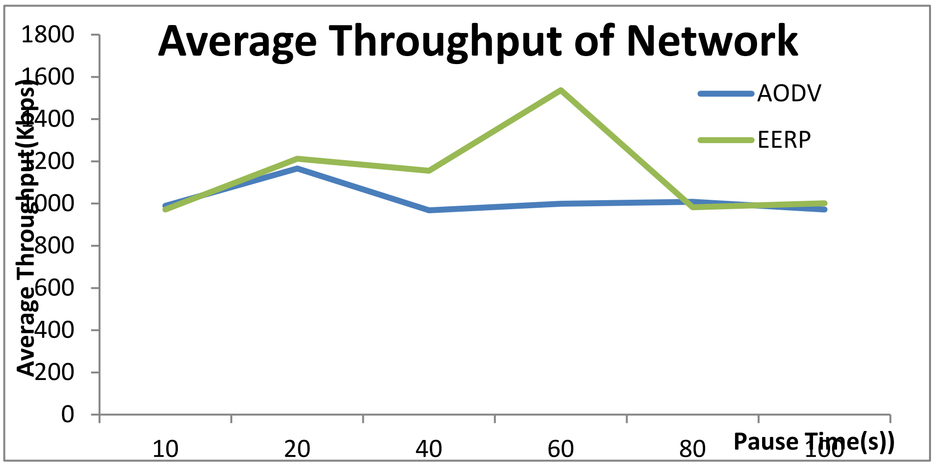

Figure 5. Plot of Average Throughput of the Network Vs Pause Time

The simulation results show that the proposed scheme achieves a better average throughput than AODV, when the scenario was run for varying pause times.

Average power consumption:

Energy is one of the limited resources in a mobile ad hoc network and Average power consumption is a measure of the average power consumption in the network.

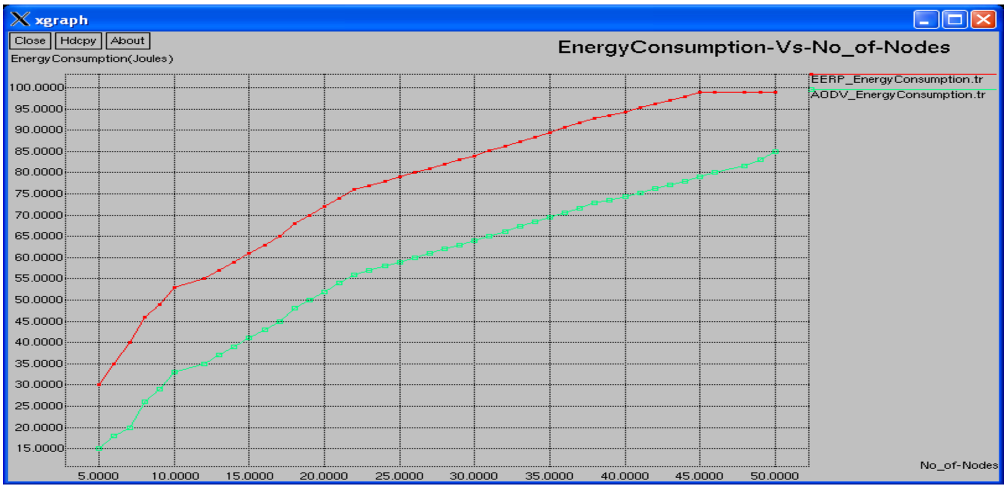

Figure 6. Plot of Energy Consumption Vs Node Density

Figure 6 shows the result of the evaluation of Average energy consumption versus number of mobile nodes. It can be observed that, when we consider 2 nodes as source and destination from 10 mobile nodes, 33J is the highest energy consumed by the proposed EERP scheme after 150 seconds of simulation. Whereas, under similar conditions energy consumption of AODV is found to be 53J. Also when the number of nodes is increased to 20, 30, 40 and so on, similar results can be obtained in terms of energy consumed by the nodes.

VI. CONCLUSION

This paper addresses the energy efficient delivery of data in a mobile ad-hoc network. It utilizes the broadcast nature of the wireless medium and achieves reduced energy consumption, by the selection of the relay node with sufficient energy as the relay node. It is found that the selection of energy efficient forwarding candidates and putting the inactive nodes to sleep state greatly achieves better network capacity, by optimizing the power used in transmission.

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