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Implementation of Energy Efficient Routing Protocol for MANETs based on AODV

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Abstract: **In MANET, all nodes are mobile in nature and having limited battery charge. Continuous change in position and connection degrades the battery charge of the nodes therefore it is necessary to save battery of those nodes which are having low battery so that the network lifetime can be long lasting. It is really very significant to increase lifetime of MANET. In order to enhance the lifetime of MANET; energy efficient techniques are required. In this paper, an energy efficient routing protocol is proposed for this purpose which is based on AODV. In the present work, we propose an energy efficient routing protocol viz. EERP (Energy Efficient Routing Protocol). The protocol reduces the transmission power of a node which is part of an active route if next hop node is closer. The distance between two consecutive nodes is calculated based on RSS (received signal strength) from next hop during the route reply process. If the RSS is high, it implies that nodes are closer; as a result lesser transmission power will be required to send data. This in turn reduces battery consumption. The performance analysis of proposed protocol is analyzed using Qualnet 5.0.2 network simulator and it is compared with existing AODV routing protocol It is found that the performance of proposed EERP protocol is better in terms of in terms of residual battery, energy consumed in transmit and receive mode, average jitter, end-to-end delay and throughput. Energy consumption is found to be 12% less than existing AODV protocol.**

Keywords: Ad-Hoc Networks, Throughput, Jitter, End-To-End Delay, Transmission Power, EERP*.*

I. INTRODUCTION

In recent years, mobile ad-hoc networks have played an increasingly important role in a wide range of applications. A wireless ad hoc network consists of various mobile, self organized and battery–powered wireless devices, such as PDAs, laptops and cellular phones. These mobile devices use nickel cadmium or lithium-ion batteries as their power providers and each of them may have different battery capacity and power dissipation characteristics. On the other hand, applications in ad-hoc networks, such as multimedia transmission service, video conference, IP telephony and interactive games, require the network to support high data throughput and long lifetime at faster processors and higher-resolution devices. However, nowadays with battery technology lagging behind, battery on laptops, handheld PCs and cellular phones can only last a few a few hours of work. Although battery capacity has been increased by 10% to 15% per year, it still does not keep up with the increasing power demands from power intensive applications on wireless devices. Battery lifetime therefore emerges as a key factor that affects the performance of mobile ad hoc networks. Carefully scheduling and budgeting battery power in ad-hoc networks has become an urgent and critical issue [1].

AODV protocol does not consider the power usage of node, it optimize the routing with lowest delay. The mobile ad-hoc network are energy constrained system since they consists of battery operated nodes having limited energy. From the perspective of energy, the shortest path is not always the finest path. If the same paths are being utilized repeatedly due to the minimum number of route, the nodes energy along these routes will be consumed quickly and they may exhaust their batteries faster. The energy conservation of the network system is a key problem especially in the situation such as military areas, disaster relief, classrooms and conferences. The consequence is that the network may become disconnected leaving disparity in the energy, and eventually disconnected sub-networks. Therefore, the shortest path algorithm is not necessary the most suitable metric to be adopted for routing decision in ad hoc networks.

The present work proposes an enhanced AODV protocol viz. EERP (energy efficient routing protocol) which increases the battery lifetime of MANET nodes by reducing the transmission power of the nearby nodes. The paper is organized as follows: First part gives the introduction of the ad hoc network. Second section describes the related work done in the field of energy efficiency. Third part explains about the need of energy management in ad hoc networks. Section four describes types of MANET routing protocols and focuses on existing AODV protocol. Fifth part gives the algorithm for proposed AODV protocol. Various performance parameters required for simulation are discussed in section six. Results found are discussed in section seven. Finally the conclusion in section eight gives the gist of the paper.

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II. RELATED WORK

To implement such protocol, an extensive literature survey has been done for energy-aware routing protocols of MANETs. Different energy-aware routing protocols of MANETs are being proposed. The work done in [1] uses a sleep mechanism for decreasing energy consumption in which results in the stability of the network. Sajjad considered in [2] a new ‘‘topology control game’’ for wireless ad hoc networks in which nodes attempt to selfishly minimize their own energy consumption. The work in [3] surveys and classifies conventional and energy efficient routing protocols. This work classifies a number of energy aware routing schemes. The work done in [4] first explain that the minimum energy routing schemes in the literature could fail without considering the routing overhead involved and node mobility and then propose a more accurate analytical model to track the energy consumptions due to various factors, and a simple energy-efficient routing scheme PEER to improve the performance during path discovery and in mobility scenarios. Deying Li in [5] proposes three energy efficient multicast routing methods named as a Steiner tree based method, a node-join tree greedy (NJT) method and a tree-join-tree greedy (TJT) method. Next [6] uses a hibernation mechanism, a beacon inhibition mechanism, and a low-latency next-hop selection mechanism for reducing the power consumption in the MAC protocol. The available energy-efficient routing protocols from transmission power control and load distribution approaches have been analyzed in [7]. In [8] the work uses hello packet broadcast mechanism to reduce the routing overhead and improve the efficiency. The proposed protocol is another attempt to provide an energy efficient mechanism in ad hoc network. In this protocol, the battery lifetime of MANET nodes is increased by reducing the transmission power of the nearby nodes.

III. NEED FOR ENERGY MANAGEMENT IN AD HOC NETWORKS

The energy efficiency of a node is defined as the ratio of the amount of data delivered by the node to the total energy expanded. The main reasons for energy management in ad- hoc networks are:-

- Limited energy reserve.
- Difficulties in replacing the batteries.

Table Driven Protocol (Proactive): These protocols are also called as proactive protocols since they maintain the routing information even before it is needed. Each and every node in the network maintains routing information to every other node in the network. Routes information is generally kept in the routing tables and is periodically update as the network topology changes.

On Demand routing protocols (Reactive): In order to overcome limitations of the proactive protocols in mobile environments, reactive protocols such as AODV, TORA, DSR, and ABR are used.

- Lack of central coordination.
- Constraints on the battery sources.
- Selection of optimal transmission power.
- Channel utilization.

In ad-hoc networks, power is the main concern, as we have seen that due to less energy of the nodes they never retain for long time in the network as well as they are [2].

Hence due to low power of node following problems may arise:

- Node may detach from the network due to less energy level.
- Node may not function properly.
- Whole network may affect due to this node.

So our aim is:

- To reduce the transmission power of a node (using AODV) which is a part of an active route, if next hop node is closer?
- The distance between the nodes can be calculated based on RSS (received signal strength) from next hop during the route reply process.
- If this RSS is high, nodes are closer and lesser transmission power can be used to send data. This is turn reduces battery consumption. Also it improves throughput and delay.

IV. MANET ROUTING PROTOCOLS

The figure1 depicts three types of routing protocols in MANET: table driven, on-demand driven and hybrid routing protocol. In case of table driven routing protocol, the packets will be sent continuously in comparison to on-demand driven routing protocol. Reactive or on demand routing protocols works only on demand.

These three routing protocols are further divided into several protocols. Among all these protocols, AODV is being considered for energy efficiency. AODV is supposed to be better for this purpose because it is on-demand with route maintenance phase in its process.

These protocols are also called reactive protocols since they do not maintain routing information or routing activity at the network nodes if there is no communication. If a node wants to send a packet to another node then this protocol searches for the route in an on-demand manner and establishes the connection in order to transmit and receive the packet .The route discovery usually occurs by flooding the route request packets throughout the network. In on demand protocols, query/response packets are used to discover (possible more than) one route to a given destination. These control packets are usually smaller than the control packets used for routing table updates in proactive schemes, thus causing less overhead.

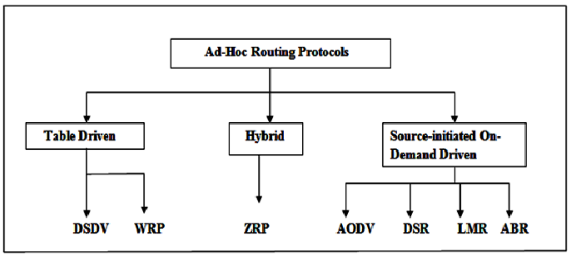

Figure1: Classification of Routing Protocol

Hybrid routing protocols: Hybrid routing protocols combine table based routing protocols with on demand routing protocols. They use distance-vectors for more precise metrics to establish the best paths to destination networks, and report routing information only when there is a change in the topology of the network. Zone Routing Protocol (ZRP) is an example of a Hybrid routing protocol [3].

4.1 AODV Routing Algorithm

There are three phases for operation of AODV routing protocol.

(1) Route establishment: This phase generates route request packet to discover best shortest path. It consists of two processes:

(a) Generate request

(b) Processing and forwarding route request.

(2) Route handling: This phase handles the route requests generated. Once the route is established all the packets will be sent to the destination through the same route. It includes two processes:

(a) Generating route replies.

(b) Receiving and forwarding route replies.

(3) Route Termination: It describes when the route will terminate. If there will be any error in the route then route error packet is sent to the sender and intermediate nodes will indicate alternative path to recover from the error. This is explained in the route error message, route expiry and route deletion process [3].

V. PERFORMANCE PARAMETERS

The performance parameters are defined as follows [5]:

- Average Jitter

  Jitter is the variation in time between packets arriving, caused by network congestion, timing drift or route change. A jitter buffer can be used to handle jitter.

- Throughput

  Throughput is the average rate of successful message delivery over a communication channel. It is usually measured in bits per second (bit/sec), and sometimes in data packets per second.

- End-to-End delay

  Average amount of time taken by a packet to go from source to destination. This includes all possible delays caused by route discovery latency, retransmission delays and transfer times.

VI. RESULTS AND DISCUSSION

The performance parameters viz. residual battery, throughput, end to end delay and jitter, packets received, energy consumed of AODV and EERP are compared in this section. The simulation is performed using Qualnet 5.0.2 simulator.

The simulation tool used is Qualnet simulator. Qualnet provides a comprehensive set of tools with all the components for custom network modeling and simulation projects. QualNet's unparalleled speed, scalability, and fidelity make it easy for modelers to optimize existing networks through quick model setup and in-depth analysis tools. QualNet has several core components: (1) architect (2) analyzer (3) Packet tracer (4) File editor. The parameters used for simulation are mentioned in Table 1.

Table 1: Simulation Parameters Used

Routing Protocol	AODV/EERP
Packet size	512 bytes
Battery Model	Linear
Energy Model	Generic
Threshold value for RSS	-75(in dBm)
Simulation Time	1000 sec
Number of Links	2,4,6,8,10

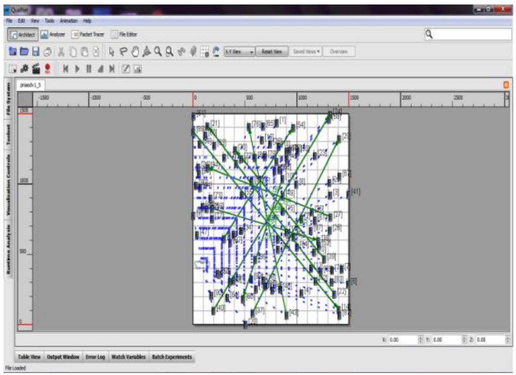

Figure 2: Test scenario

Description of scenario:

- To evaluate the performance of proposed algorithm a scenario of 100 nodes with 2,4,6,8 and 10 CBR (constant bit rate) links have been created in Qualnet.
- Since route request phase in EERP protocol is enhanced by threshold RSS (received signal strength) equals to -83 (in dBm).In route reply phase, the results for the scenario are calculated at THRSS (threshold RSS) value equals to -75 (in dBm). The default value of THRSS for RREP is -85 (in dBm).

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An extensive and rigorous simulation has been performed to evaluate this threshold value for RREQ and RREP phase for the proposed EERP algorithm.

Figure 3 shows average residual battery as a function of number of links. It is found that the average residual battery of the network is greater in EERP as compared to AODV as the number of links increases. In case of EERP, lesser transmission power is used to send data if the node is closer, therefore residual battery is greater as compared to AODV. For 10 numbers of links, 0.491% improvement is found in EERP.

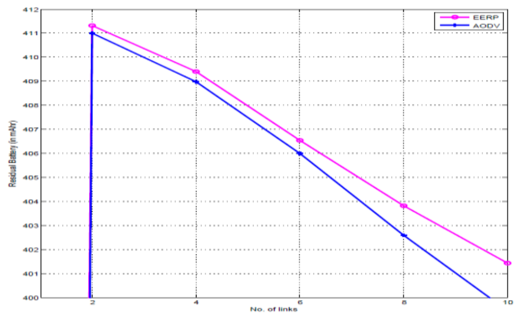

Figure 3: Residual Battery Vs Number of Links

Figure 4 illustrates the result for average end-to-end delay as a function of number of links. It is observed that delay in EERP is decreasing as compared to AODV. This is due to fact that the node in the EERP uses lesser transmission power for transmission. This result in decreased interference in the network hence the channel will remain idle for more time and the other network nodes will be able to transfer the packet at faster rate and they can reach up to the destination with lesser delay or at a faster rate. For 8 number of links, delay is reduced by 18.2% in EERP.

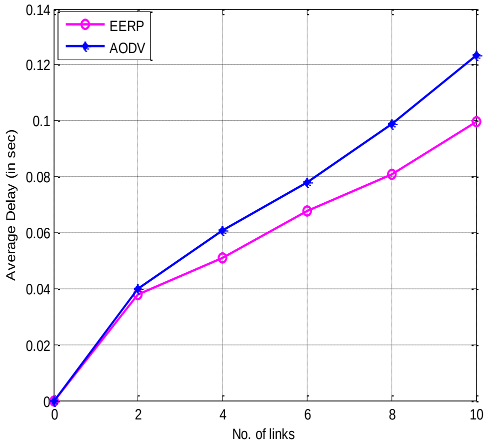

Figure 4: Average End-to-End Delay Vs Number of Links

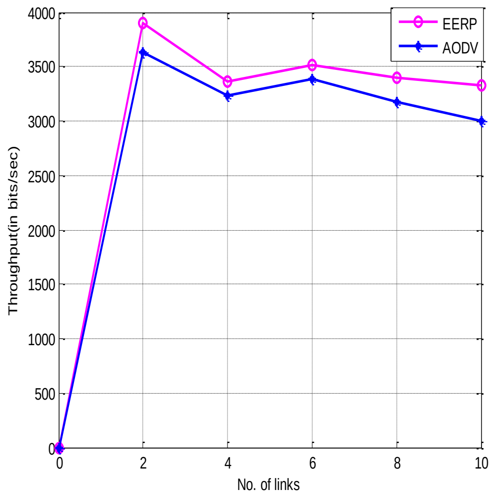

Figure 5: Throughput Vs Number of Links

The figure 5 depicts the graph for throughput with the number of links. It is clearly shows that throughput of EERP is better as compared to AODV.As we conclude from figure 4 that EERP offers lesser delay and a low delay in the network translates into higher throughput. For 8 number of link, 7.21% improvement is found in EERP.

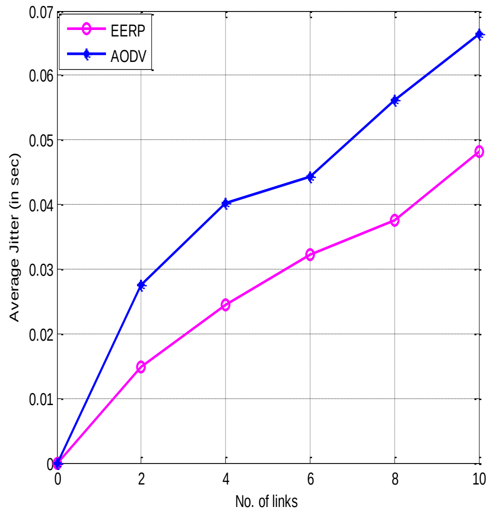

Figure 6: Average Jitter Vs Number of Links

Figure 6 shows the graph for average jitter with increase in the number of links. It depicts that the time interval between two successive packets is greater in AODV as compared to EERP. In case of EERP, due to less interference the availability of BW or channel is more. It results in lesser time difference between packets arrival at the receiver which, in turn reduced jitter. For 8 numbers of links, 33% improvement is found in EERP.

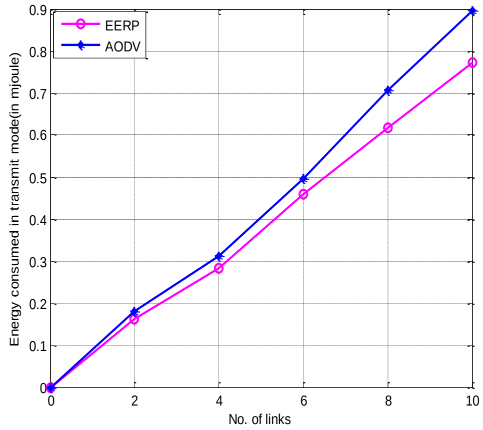

Figure 7: Energy Consumed in Transmit mode Vs Number of Links

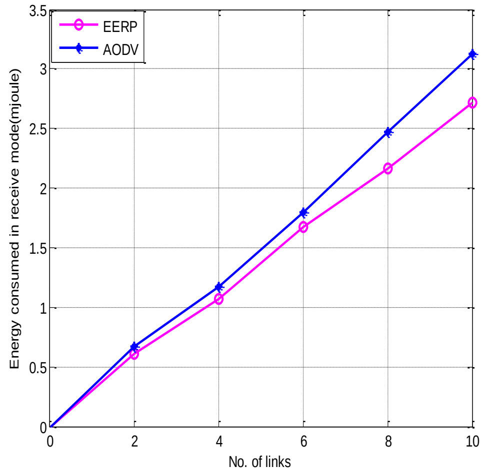

Figure 8: Energy Consumed in Receive mode Vs Number of Links

The figure 7 and 8 shows the graph for energy consumed in transmit and receive mode as a function of number of links respectively.Energy consumed is around 12% lesser in both the modes in case of EERP since transmission is done at reduced RSS value.

Figure 9 shows the packets received in our scenarios as number of links increases. The graph illustrates that packets received are greater in EERP as compared to AODV because EERP offers lesser delay. As a result of this, more packets will reach up to the destination.

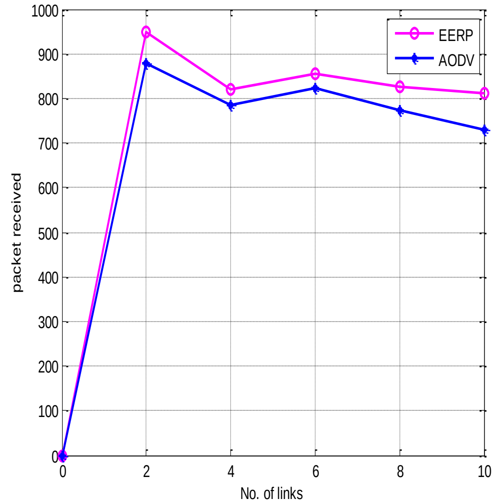

Figure 9: Packets received Vs Number of Links

VII. CONCLUSION

Reducing power consumption in ad-hoc networks has received increased attention among researchers in recent years. Since a node is used as a host and router, design of energy efficient routing protocols must address reducing of power consumption from the view point of the node and network. Although energy efficiency is not the design goals of MANET routing protocols, each routing protocol reacted in a different way with energy aware metrics. This is due to the route discovery and maintenance mechanisms of these routing protocols. In this paper, we evaluate the energy efficiency of existing well known MANETs routing protocols viz. AODV. We propose mechanism which provides energy efficient algorithm for AODV routing protocol. The mechanism reduces the transmission power of a node which is part of an active route if next hop node is closer. The distance can be calculated based on RSS (received signal strength) from next hop during the route reply process. In request phase, if the RSS is high than threshold value then that node will consider for forwarding the packet. In reply phase, if the RSS is high, it implies that nodes are closer; as a result lesser transmission power will be required to send data. At this point we reduce the transmission power of the node. This in turn reduces battery consumption. This energy efficient routing mechanism is incorporated into AODV and provided EERP. Transmission power control which reduces interference extend the battery lifetime of network.

The simulation has been carried out in Qualnet 5.0.2 and the performance parameters values have been evaluated. For evaluation analysis, some parameters are being considered to compare both AODV and EERP such as residual battery and throughput which is increasing. Average jitter, energy consumed and delay is decreasing. Consequently EERP is better than existing AODV. EERP improves the performance of route selection of AODV due to the fact that it minimizes the interference as a result of transmission power control.

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