Energy and Throughput Efficient Routing Protocols in Mobile Ad Hoc Wireless Sensor Network

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Abstract- *For good Quality of Service in Mobile Ad Hoc Network is that, better protocols should be used. Mobile Ad hoc Network is collection of mobile or sensor nodes which are used for transferring information in a particular area. To achieve good protocol efficiency, two key issues to be considered are, low control overhead and low energy consumption. To reduce energy consumption and routing overhead, an enhanced routing algorithm, EEDSR (Energy Efficient Dynamic Source Routing) with local route enhancement model for DSR (Dynamic Source Routing) can be implemented. Comparisons based on routing overhead, energy and throughput is done between EEDSR and EEAODV (Energy Efficient Ad Hoc on Demand Distance Vector) and AODV (Ad Hoc on Demand Distance Vector) protocols using NS-2.34 Simulator. Simulation results have shown that EEDSR protocol perform well with lower energy consumption and high throughput as compared to EEAODV and AODV..*

Keywords- Ad Hoc, Load Balancing, Route Stability, AODV protocol, DSR protocol, DSDV, LEACH protocol

I. INTRODUCTION

The wireless technologies have penetrated everyone's life in various ways in the recent past. An ad hoc network is a dynamically reconfigurable wireless network with no fixed wired infrastructure. In a wireless ad-hoc sensor network (WASN), mobile nodes with the help of other nodes forward a packet to the destination due to the limited range of each mobile host's wireless transmission. All nodes in a network are dynamically movable since they are distributed [5]. Due to the mobility of nodes, some pairs of nodes may not be able to communicate directly with each other. Low control overhead and Low energy consumption are two key issues in wireless ad hoc sensor networks to improve protocol efficiency [3]. They decide the quality of service provided by the protocol. Dynamic Source Routing (DSR) and AODV (Ad hoc on demand distance vector) are preferred routing protocols in wireless sensor networks. The routing overhead of DSR and AODV is a drawback in power-constrained environment which is directly proportional to the path length [4]. This Paper presents enhanced and efficient routing algorithms, namely EEDSR and EEAODV with a local route low energy consumption model for DSR and AODV. This model reduces the routing overhead and consumes less energy during data transfer and thus improves the efficiency of Ad Hoc network.

II. ROUTNG PROTOCOL OF ADHOC NETWORK

Increase in data output rate, reducing the transmission power and hence increasing the network capacity can be achieved by using peer-to-peer network model. Initially two protocols namely NOAH (No ad Hoc) Protocol and HYBRID protocol were used where NOAH was used for getting better integration with existing cellular networks. It supports the static routing [7]. It is a protocol which is used in the UMTS module. In the NOAH protocol, data packets of all mobile stations will be all directly forwarded to Base Station (BS). Then not only data but also signaling will be forwarded by BS, and feedback data message will also be retransmitted to BS. The NOAH protocol does not generate any routing data packets, so routing load is 0. The HYBRID protocol supports the central node (BS) communication model and peer-to-peer mode. The process of routing search depends on routing information. Each node maintains a routing list for itself. When node needs to transmit the information, it firstly check routing table maintained by it. Their simulation results showed that, with the increase of users needing services the number of user access to the network reduces gradually for all network models, but the user access rate of the hybrid routing protocol is higher than the traditional PMP mode and NOAH. Simultaneously the energy consumption of HYBRID is significantly lower than the NOAH. The bandwidth and power constraints are the main concerns in current wireless networks because multihop ad hoc mobile wireless networks rely on each node in the network to act as a router and packet forwarder [2]. In recent years, protocols that build routes based on-demand have been proposed. The major goal of on-demand routing protocols is to minimize control traffic overhead. The two types of on-demand routing protocols are namely, DSR (Dynamic Source Routing), and ABR (Associativity-based Routing). DSR has less overhead than ABR when the network is static. In DSR, if a node in the path becomes unreachable, a control message specifying a route error is propagated all the way back to the source to invoke a new route discovery. In contrast, in ABR the immediate upstream of a migrated node starts the LQ process to find a new partial route without intervention from the source, hence minimizing the transmission of control messages. In DSR, a route is chosen based on the shortest delay at the instance of route establishment. ABR distinctively selects a route where nodes in the path are associatively stable, spatial, and temporal and connection wise and have light load.

1.PERFORMANCE OF DSR PROTOCOL

Dynamic Source Routing (DSR) is an Ad Hoc routing protocol which is based on the theory of source-based routing rather than table-based [2]. This protocol is source-initiated rather than hop-by-hop. This Protocol is composed of two essential parts of route discovery and route maintenance. Every node maintains a cache to store recently discovered paths. When a node desires to send a packet to some node, it first checks its entry in the cache. If it is there, then it uses that path to transmit the packet and also attach its source address on the packet. When the route is discovered, the required packets will be transmitted by the sender on the discovered route. Also an entry in the cache will be inserted for the future use. When a data packet is received by any intermediate node, it first checks whether the packet is meant for itself or not. If it is meant for itself (i.e. the intermediate node is the destination), the packet is received otherwise the same will be forwarded using the path attached on the data packet.

A. DSR Algorithm Steps

Step 1: Node is idle.
Step 2: Receives a packet.
Step 3: Checks for data packet.
Step 4: If data packet, then it tests for destination.
Step 5: If its destination then it receives packet and goes to step 1.
Step 6: If it is not destination, then forwards the packet following the route and goes to step 1.
Step 7: If it is not data packet then it checks for route reply.
Step 8: If yes then it checks itself for receiving route reply.
Step 9: If it is for itself then it has an entry in cache and transmits using the route and goes to step 1.
Step 10: If it’s not for itself then it forwards the packet to origin and also has a new entry in cache for that path.
Step 11: If packet is not for a route reply then it sends back a route reply packet to itself if it’s a destination or it’s a neighbor. Else broadcasts the packet.
Step 12: If node wants to send data then it checks for entry in cache.
Step 13: If there is valid entry then it transmits the packet using route in cache and goes to step 1.
Step 14: If no valid entry exist then it broadcasts a route request packet and waits for route discovery and goes to step 1.

2. PERFORMANCE OF AODV PROTOCOL

The Ad Hoc On-Demand Distance-Vector Protocol (AODV) is a distance vector routing for mobile ad-hoc networks. AODV is an on-demand routing approach, i.e. there are no periodical exchanges of routing information. It consists of two phases namely route discovery and route maintenance.

A. Route Discovery Phase and Algorithm

When a node wants to send a data packet to a destination node, entries in route table are checked to ensure whether there is a current route to that destination node or not. If it is there, the data packet is forwarded to the appropriate next hop directing towards the destination. If it is absent, then route discovery process is initiated. AODV initiates a route discovery process using Route Request (RREQ) and Route Reply (RREP) [6]. The source node creates a RREQ packet containing its IP address, its current sequence number, the destination’s IP address, the destination’s last sequence number and broadcast ID. The steps of algorithm are as follows:

Step 1: The source node ‘S’ broadcast the ROUTE-REQUEST to all its neighbors.
Step 2: After getting the ROUTE-REQUEST the neighbor nodes check the ROUTE-ID, whether the ROUTEREQUEST has been received before.
Step 3: If the ROUTE-REQUEST packet has been already received by the neighbor node, then it discards the packet.
Step 4: Otherwise, a reverse path is established between the source and the neighbor node.
Step 5: If this node is not the destination or having no path to the destination, then
Step 6: Repeat step 1 and onwards (neighbor node in place of source node).
Step 7: When the ROUTE-REQUEST packet finds the destination node or node having path to the destination, the destination node unicast the ROUTE-REPLY towards the source node.
Step 8: When the ROUTE-REPLY packet reach to the source node following the path of intermediate nodes, the route is established in the reverse way i.e. from the destination to the source
Step 9: The route is established, and the data packets can be sent through the established route.

B. Route Maintenance Phase and Algorithm

A route discovered between a source node and destination node is maintained as long as it is needed by source node. Since there is movement of nodes in a network and if the source node moves during an active session, it can reinitiate route discovery mechanism in order to establish a new route to destination. Conversely, if the destination node or some intermediate node moves, the node upstream of the break initiates Route Error (RERR) message to the affected active upstream neighbor nodes. The steps of algorithm are as follows:

Step 1: Established route is traversed to find the static nodes.
Step 2: If no static nodes are found in the route, then regular AODV route-maintenance is used.
Step 3: If static nodes are found in the established route, then a buffer is attached to every static node.
Step 4: In case of link failure, ROUTE-ERR message is generated at the predecessor node of the broken link.
Step 5: ROUTE-ERR message is sent to the first static node while passing it towards the Source (hop-by-hop).
Step 6: After receiving the ROUTE-ERR message, the static node declares the link failure.
Step 7: Packet delivery stops at static node and these packets are then stored in the buffer attached to the static node.
Step 8: Route-caching or route-discovery is applied on the static node instead of source node (based on feasibility).

III. IMPLEMENTATON OF EEAODV PROTOCOL

As the size of network grows, various performance metrics of AODV begin decreasing [1]. The energy consumption is also more while data transfer and routing overhead increases in worst cases of unavailability of routes. A protocol called EEAODV (Energy Efficient Ad Hoc on demand Distance Vector) is presented based on the model for reducing the packet overhead and energy consumption using hello packets to exchange the local routes. In this algorithm, during route discovery from the source to the destination the energy values along the route are accumulated in the RREQ packets. At the destination or intermediate node these values are copied into the RREP packet which is transmitted back to the source. The steps are as follows:
Step 1: Discover the neighbor node by sending hello packets along with route information.
Step 2: If no route is available, send the hello packet alone.
Step 3: When RREQ is received, check the local route table to know whether any Neighbor with route to destination exists.
Step 4: If so, send RREP. If not, broadcast RREQ.

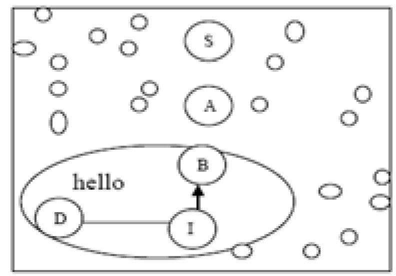

Fig.1. Exchange of hello Packets

In Fig. 1 node I act as an intermediate node which has route to the destination D. It sends and receives hello packets to their nearby nodes. After node I sends the hello packet to node B, node B updates the information to source S through the return of RREP shown in Fig. 2 If route information is not available, the control packets are exchanged as in AODV. RREQ message is initially sent from source node S to node A, and then to B, since node B has already got hello message from D by using Fig.3.1. RREQ is only sent up to B. Node B simply sends the RREP message to node A. Finally, the node A sends the RREP message to source node S.

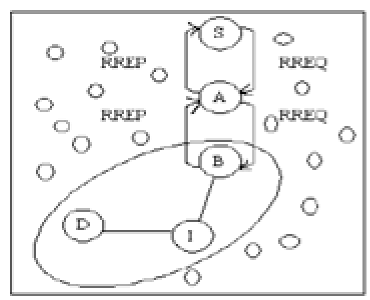

Fig.2. RREQ & RREP Messages

IV. IMPLEMENTATON OF EEDSR PROTOCOL

The limitations of DSR protocol is that it's not scalable to large networks and requires more processing resources than most other protocols. EEDSR (Energy Efficient Dynamic Source Routing) performs well with large network along with low control and packet overhead. It does not support beacon messages. It broadcasts simple RREQ message without destination information. When a neighbor node gets this message it updates their neighbor table and save its information. When the original RREQ message appear, then the nodes uses this information to enhance the route. The algorithm steps are as follows:

Step 1: Discover the neighbor node by sending a RREQ packet along with route information (with destination information).
Step 2: When RREQ is received, check the local route table to know whether any neighbor with route to destination exists.

Step 3: If so, send RREP. If not, broadcast RREQ.

V. DESIGN AND SIMULATON

Simulation is carried out in Network Simulator (NS-2.34). It accepts a scenario file as input which describes the exact motion of each node and exact packets originated by each node. It also describes the exact time at which each change in motion or packet origination that occurs. The detailed trace file created by each run is stored to disk and analyzed using a variety of scripts. One such script called as file *.tr which counts the number of packets successfully delivered and the length of the paths taken by the packets. Simulation is done in a physical topology area of 500m × 500m that uses bidirectional links. Flat grid topology is used. At start of simulation, each node waits for a pause time and then moves towards a destination with a speed lying between 0-60 m/sec. On reaching the destination, it pauses again and repeats the above procedure till the end of the simulation time. Mobility models were created for the simulations using the varying number of nodes from 40-100. Initial energy of nodes is assumed to be 1000 Joules. The mobility model used is random waypoint model. Comparison of the routing protocols is done on mainly energy consumption of nodes and their sending rates and throughput of the network.

VI. COMPARATIVE RESULTS

A. Comparison based on Energy Consumption.

Fig.3 shows the comparison between AODV, EEAODV, and EEDSR based on average energy of nodes. Results show that the total energy consumption of nodes in EEAODV is lesser as compared to AODV. But EEDSR performs well as compared to both AODV & EEAODV. The numbers of nodes are varied from 40 to 80 for efficiency.

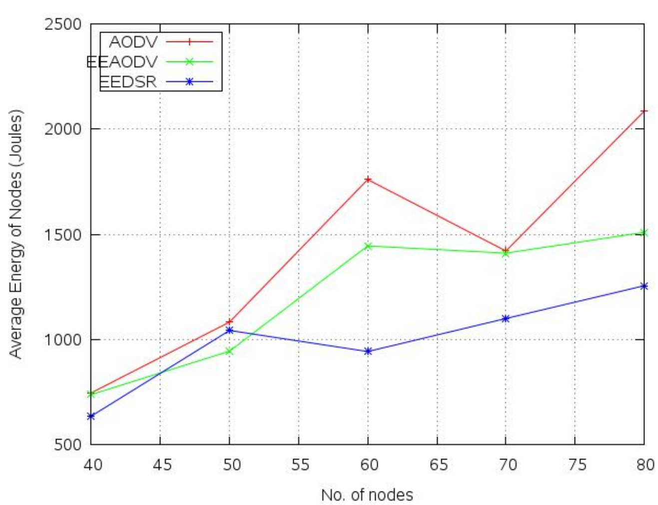

Fig.3. Average Energy of Nodes

Fig.4 shows the total energy consumption of nodes during data transfer. The data rate varies as the numbers of nodes vary i.e from 0 to 50. Results show that EEAODV consumes lesser energy when nodes are varied from 10 to 40 as compared to AODV. But AODV consumes constant energy when number of nodes increases beyond 30. EEDSR consumes less energy till 30 nodes but shows linear performance after 30 nodes.

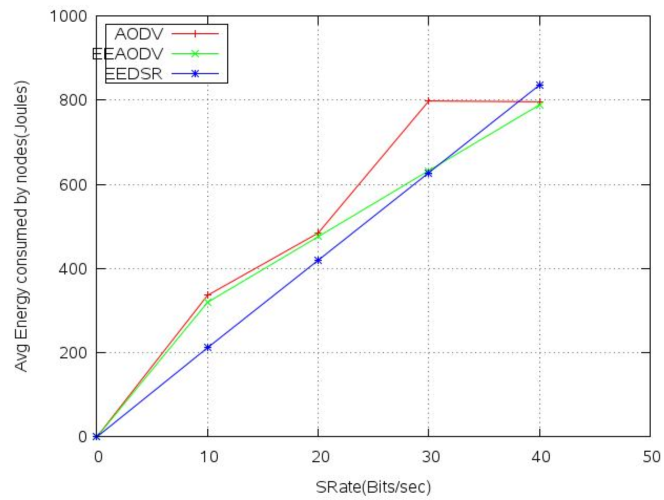

Fig.4. Average energy consumption of nodes during data transfer

B. Comparison based on Throughput

The throughput of a network is calculated based on ratio of total number of packets sent and total number of packets received. Fig.5 shows the result of packet overhead of network with respect to number of nodes varied in a given random area.

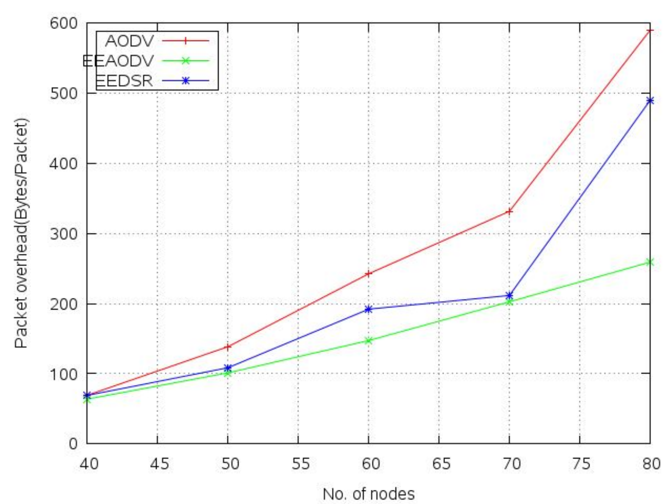

Fig.5. Packet overhead of nodes

The throughputs of AODV, EEAODV and EEDSR are in bits per seconds. AODV achieved 590 bits/sec when number of nodes was 80, while EEAODV recorded 490 bits/sec. As the pause time increases and more network routes are discovered, AODV throughput drops as packet overhead goes on increasing when number of nodes is increased. The EEDSR shows better throughput as compared to AODV and EEAODV. The maximum packet overhead recorded when number of nodes were 80 was 260 bits/sec as shown in Fig. 5 This shows the effect of variation in pause time of a mobile node. All three protocols deliver a greater percentage of the originated data packet at low node mobility. Fig.6 shows the packet overhead of nodes during data sending. The sending rate is varied from 0 to 400 bits/sec. Results show that AODV has larger packet overhead as compared to EE ADOV and EEDSR. But when the sending rate increases beyond 300 bits/sec the packet overhead becomes constant for all the three protocols. EEDSR has low routing overhead as compared to AODV and EEADOV. Maximum overhead recorded for AODV is 70.

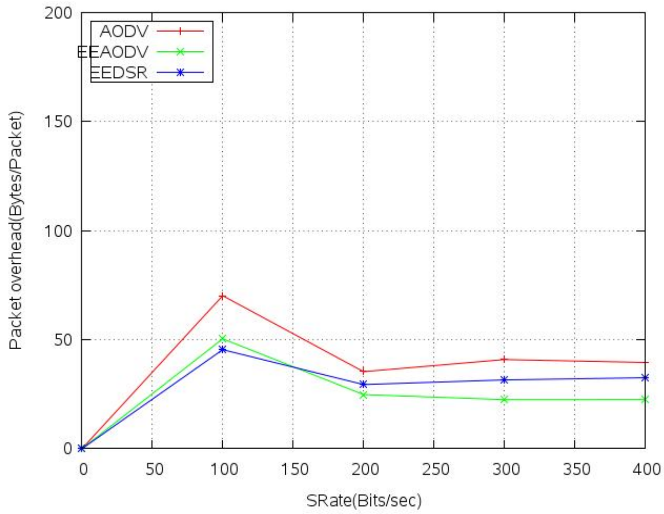

Fig.6. Packet overhead during data sending.

VII. CONCLUSION AND FUTURE SCOPE

The simulated graphs show that EEAODV and EEDSR routing protocols were optimized to obtain a higher throughput. EEDSR and EEAODV adapts quickly to routing changes by reduction of sending route request packet. Throughput graph shows that EEDSR has lower packet overhead than AODV and EEAODV. It also consumes less energy. The work can be extended to include the study of energy efficiency by implementing shortest path algorithm or DBF algorithm in AODV's Route Discovery stage.

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