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Evaluation of Routing Algorithm for Ad-hoc and Wireless Sensor Network Protocol

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***Abstract*—** Low control overhead and Low energy consumption are two key issues in wireless ad hoc sensor networks to improve protocol efficiency. 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. This is directly proportional to the path length. 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 sensor network.

***Index Term*—** Wireless Sensor Network, EEAODV, EEDSR, Ad-hoc

I. INTRODUCTION

A sensor node is capable of performing some processing, gathering sensory information and communicating with other connected nodes in the network. A set of sensor node is the basic component of the sensor network. Fig 1.2 shows the basic sensor node architecture. It has mainly four components, namely sensing unit, processing unit, communication unit and power unit.

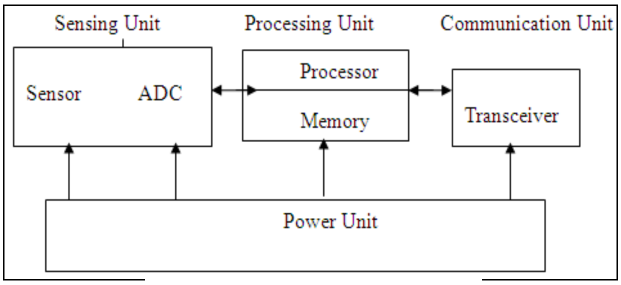

Fig 1: Sensor Node architecture

Sensing units are usually made up of application specific sensors and ADC's (Analog to Digital Convertors) which digitalizes the analog signals produced by the sensors when they sense particular phenomenon. The processing unit has a processor or controller which performs tasks, processes data and controls the functionality of other components in the sensor node. Another element in the processing unit is memory. Memory requirements are very much application dependent. Two categories of memory based on the purpose of storage are: user memory used for storing application related or personal data, and program memory used for programming the device. Program memory also contains identification data of the device if present. Flash memory is used due to their cost and storage capacity [2].

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Communication unit has transceiver, which is nothing but combination of both, transmitter and receiver. It has built in state machine which performs operations automatically. The operational states are transmit, receive, idle, and sleep. Most transceivers operating in idle mode have a power consumption almost equal to the power consumed in receive mode. Thus, it is better to completely shut down the transceiver rather than leave it in the idle mode when it is not transmitting or receiving. A significant amount of power is consumed when switching from sleep mode to transmit mode in order to transmit a packet. The power unit is used by the sensor node for consuming power for sensing, communicating and data processing. More energy is required for data communication than any other process. Power is stored either in batteries or capacitors. Batteries, both rechargeable and non-rechargeable, are the main source of power supply for sensor nodes. They are also classified according to electrochemical material used for the electrodes such as NiCd (nickel-cadmium), NiZn (nickel-zinc), NiMH (nickel-metal hydride), and lithium ion. Current sensors are able to renew their energy from solar sources, temperature differences, or vibration. Two power saving policies used are Dynamic Power Management (DPM) and Dynamic Voltage Scaling (DVS). DPM conserves power by shutting down parts of the sensor node which are not currently used or active[7]. A DVS scheme varies the power levels within the sensor node depending on the non-deterministic workload. By varying the voltage along with the frequency, it is possible to obtain quadratic reduction in power consumption.

More than a literature review, Organize related work - impose structure. Be clear as to how previous work being described relates to your own. The reader should not be left wondering why you've described something!! Critique the existing work - Where is it strong where is it weak? What are the unreasonable/undesirable assumptions? Identify opportunities for more research (i.e., your thesis) Are there unaddressed, or more important related topics? After reading this chapter, one should understand the motivation for and importance of your thesis. You should clearly and precisely define all of the key concepts dealt with in the rest of the thesis, and teach the reader what s/he needs to know to understand the rest of the thesis.

II. PERFORMANCE METRICS

The project focuses on two performance metrics which are quantitatively measured. The performance metrics are important to measure the performance and activities that are running in NS-2 simulation. The performance metrics are energy consumption of nodes, their sending rates and throughput which calculates packet overhead across the route.

Energy Consumption: It represents the capacity or potential of nodes to perform data transfer within given amount of time. It also decides the lifetime of the node within the network.

Throughput: It represents the total number of bits forwarded to higher layers per second. It can also be defined as the total amount of data a receiver actually receives from sender divided by the time taken by the receiver to obtain the last packet. It also represents the packet overhead within the route.

The efficiency of the ad hoc sensor network depends on how well the nodes are distributed, and the network's throughput [4]. The on demand routing protocols perform well as they provide routes only when data has to be sent. The routing overhead is less in case of on demand routing protocols. Another factor that depends on the network's performance is that the total amount of energy consumed by the nodes during data transfer [9]. Here Comparisons based on Energy consumption and throughput of the ad hoc network is done between the on demand reactive protocols namely AODV (Ad Hoc on demand distance vector), EEAODV (Energy Efficient Ad Hoc on demand Distance Vector), and EEDSR (Energy Efficient Dynamic Source Routing). Following are the assumptions for designing the algorithms of ad hoc network:

Assumptions: It is assumed that all nodes wishing to communicate with other nodes within the ad hoc network are willing to participate fully in the protocols of the network.

Packets may be lost or corrupted in transmission on the wireless network. A node receiving a corrupted packet can detect the error and discard the packet. Nodes within the ad hoc network may move at any time without notice, and may even move continuously, but we assume that the speed with which nodes move is moderate with respect to the packet transmission latency and wireless transmission range of the particular underlying network hardware in use.

DSR (Dynamic Source Routing) Algorithm: Dynamic Source Routing (DSR) is an Ad Hoc routing protocol which is based on the theory of source-based routing rather than table-based. This protocol is source-initiated rather than hop-by-hop. This Protocol is composed of two essential parts of route discovery and route maintenance [12]. 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. If it is not there in the cache or the entry in cache is expired (because of long time idle), the sender broadcasts a route request packet to all of its neighbors asking for a path to the destination. The sender will be waiting till the route is discovered. During waiting time, the sender can perform other tasks such as sending/forwarding other packets. As the route request packet arrives to any of the nodes, they check from their neighbor or from their caches whether the destination asked is known or unknown. If route information is known, they send back a route reply packet to the destination otherwise they broadcast the same route request 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. The node will also maintain the age information of the entry so as to know whether the cache is fresh or not. 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. Since in Ad hoc network, any link might fail anytime. Therefore, route maintenance process will constantly monitors and will also notify the nodes if there is any failure in the path. Consequently, the nodes will change the entries of their route cache statement.

III. SR ALGORITHM STEPS

Step 1: Node is idle with initial energy

Step 2: Node receives a packet.

Step 3: Checks for data packet.

Step 4: If it is data packet, 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 on the packet
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 this route and goes to step 1.
Step 10: If it s not for itself then it forwards the packet to originator and also has a new entry in cache for this 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 its neighbor. Otherwise broadcasts the packet.
Step 12: If node wants to send data then it checks of 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.

AODV- 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 [3].

Route Discovery Phase Of AODV[5]- When a node wants to send a data packet to a destination node, the 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 toward the destination. If it is not there, the route discovery process is initiated. AODV initiates a route discovery process using Route Request (RREQ) and Route Reply (RREP). The source node will create 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 broadcast ID is incremented each time the source node initiates RREQ. Basically, the sequence numbers are used to determine the timeliness of each data packet and the broadcast ID & the IP address together form a unique identifier for RREQ so as to uniquely identify each request. The requests are sent using RREQ message and the information in connection with creation of a route is sent back in RREP message. The source node broadcasts the RREQ packet to its neighbours and then sets a timer to wait for a reply. To process the RREQ, the node sets up a reverse route entry for the source node in its route table. This helps to know how to forward a RREP to the source. Basically a lifetime is associated with the reverse route entry and if this entry is not used within this lifetime, the route information is deleted. If the RREQ is lost during transmission, the source node is allowed to broadcast again using route discovery mechanism.

The source node broadcasts the RREQ packet to its neighbours which in turn forwards the same to their neighbours and so forth. Especially, in case of large network, there is a need to control network-wide broadcasts of RREQ and to control the same; the source node uses an expanding ring search technique. In this technique, the source node sets the Time to Live (TTL) value of the RREQ to an initial start value. If there is no reply within the discovery period, the next RREQ is broadcasted with a TTL value increased by an increment value. The process of incrementing TTL value continues until a threshold value is reached, after which the RREQ is broadcasted across the entire network.

When the destination node or an intermediate node with a route to the destination receives the RREQ, it creates the RREP and unicast the same towards the source node using the node from which it received the RREQ as the next hop. When RREP is routed back along the reverse path and received by an intermediate node, it sets up a forward path entry to the destination in its routing table. When the RREP reaches the source node, it means a route from source to the destination has been established and the source node can begin the data transmission.

Route Maintenance Phase of AODV- A route discovered between a source node and destination node is maintained as long as needed by the source node. Since there is movement of nodes in mobile ad hoc network and if the source node moves during an active session, it can reinitiate route discovery mechanism 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 neighbours/nodes. Consequently, these nodes propagate the RERR to their predecessor nodes. This process continues until the source node is reached. When RERR is received by the source node, it can either stop sending the data or reinitiate the route discovery mechanism by sending a new RREQ message if the route is still required.

EEAODV (Energy Efficient Ad Hoc on demand Distance Vector) Algorithm- Though AODV is suited for Wireless Sensor Network over DSDV, it has various limitations. As the size of network grows, various performance metrics of AODV begin decreasing [1,8]. It is vulnerable to various kinds of attacks as it is based on the assumption that all nodes must cooperate and without their cooperation no route can be established. The energy consumption is also more while data transfer and routing overhead increases in worst cases of unavailability of routes. A protocol called EEAODV 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 (which has a fresh enough route to the destination) these values are copied into the RREP packet which is transmitted back to the source. The source alternates between the maximum remaining energy capacity route and minimum transmission route every time it performs route discovery. 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 neighbour with route to destination exists.
Step 4: If so, send RREP. If not, broadcast RREQ.

Performance Modeling of EEAODV- Considering the wireless ad-hoc sensor network as a cluster of single server queues in tandem, let us now have the total offered load as given in equation (1).

$$\lambda = \lambda c + \lambda d \qquad (1)$$

λc is the rate of control packets or the routing overhead and λ d is the rate of data packets. The control packets include RREQ, RREP and hello packets. Since the hello messages do not cause unnecessary overhead in the network, the RREQ and RREP packets are assumed in this work to contribute toward λ c. Hello packets are negligible and they are not taken into account. Assuming the number of hello packets to destination is the same in AODV and RE-AODV the total number of packets flowing through any node is given by the equation 2.

$$\lambda e = \lambda ce + \lambda de \qquad (2)$$

where λe denotes the total flow of packets at any node fo. $\lambda ce < \lambda c$ because there are less number of RREQ and RREP packets. That is the total routing overhead is less for RE-AODV. When there is large number of nodes in the network, λe is very small compared to the total offered load. Hence from equations (1) and (2) we derive this in equation (3).

$$\lambda e << \lambda \qquad (3)$$

For any particular routing assignment, the average number of links that a packet will traverse from the source to sink (destination) has the expected value of the number of links (hops) as given in Equation (4).

$$E\,[\text{number of links in a path}] = \lambda/\gamma \qquad (4)$$

where γ is the total external load. Taking the hop counts, EEAODV is more efficient since λc is less.

EEDSR (Energy Efficient Dynamic Source Routing) Algorithm- The limitations of DSR protocol is that this is not scalable to large networks and even requires significantly more processing resources than most other protocols [6]. EEDSR performs well with large network along with low control and packet overhead. It does not support beacon messages. Instead of beacon messages like AODV and EEAODV, it broadcasts simple RREQ message without destination information. When a neighbour node gets this message they update their neighbour table and save neighbour information. When the original RREQ message appear, then the nodes uses this information to enhance route.It has simple steps for broadcasting packets which are given below:

Step 1: Discover the neighbour 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 neighbour with route to destination exists.
Step 3: If so, send RREP. If not, broadcast RREQ.
variables that are going to be used in the study.

IV. METHODOLOGY

Simulation Environment

Simulation is carried out in Network Simulator (NS-2.34). It accepts a scenario file as input that 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 is to occur. 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 that counts the number of packets successfully delivered and the length of the paths taken by the packets as well as additional information about the internal functioning of each scripts executed

Table 1 Simulation Parameters of AODV, EEAODV, and EEDSR

Parameters	Values
Channel Type	Wireless Channel
Physical characteristics	Two-way Ground Propagation
Mac type	802.11b
Data rate	50 Kbps
Topology	500m X 500m
Routing Protocol	AODV,EEAODV, EEDSR,
Number of Nodes	Vary from 40 to 100
Transmit Power	0.005 W
Packet Size	512 bytes
Mobility Model	Random Way Point
Simulation Time	200 sec
Traffic Source	CBR
Speed	0-60 m/sec

Simulation is done in a physical topology area of 500m × 500m which uses bidirectional links. Topology used is Flat grid. 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. Table 2 summarizes the general parameters of routing protocols.

V. EXPERIMENTAL RESULT

5.1 Comparison based on Energy Consumption

The initial energy of the nodes is 1000 Joules. Fig 2 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 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.

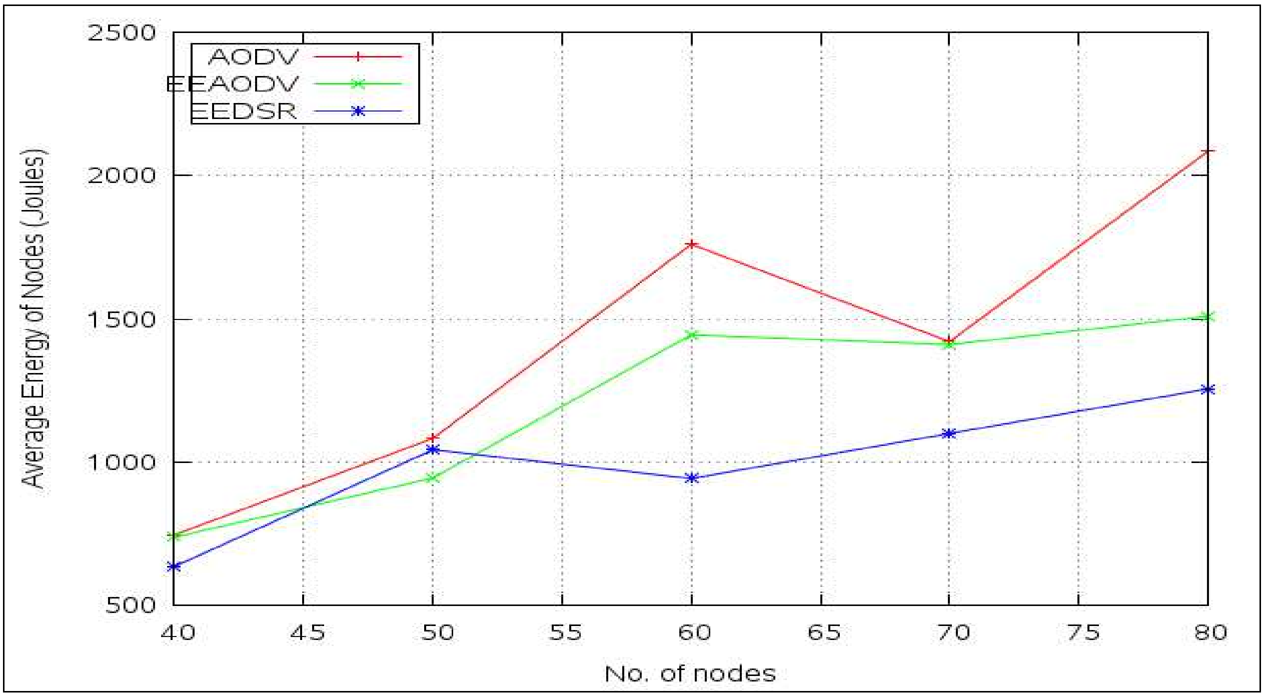

Fig.2 Average Energy of Nodes

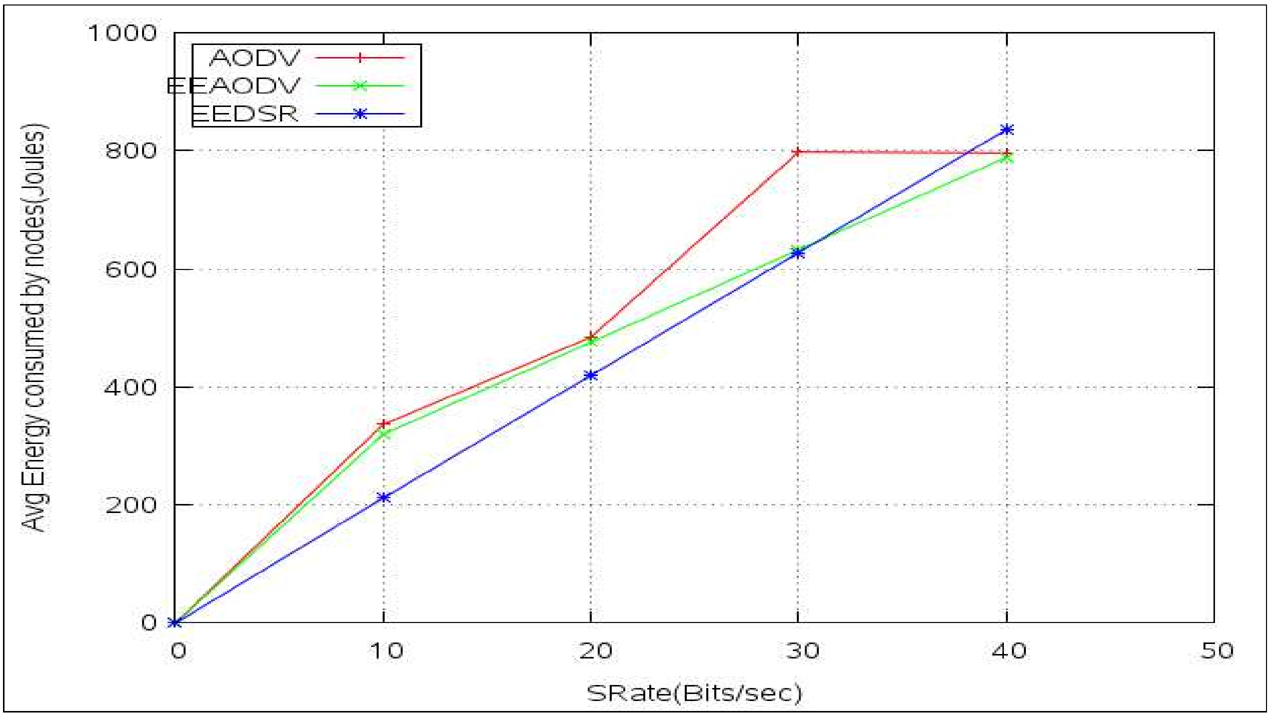

Fig.3 Average energy consumption of nodes during data sending

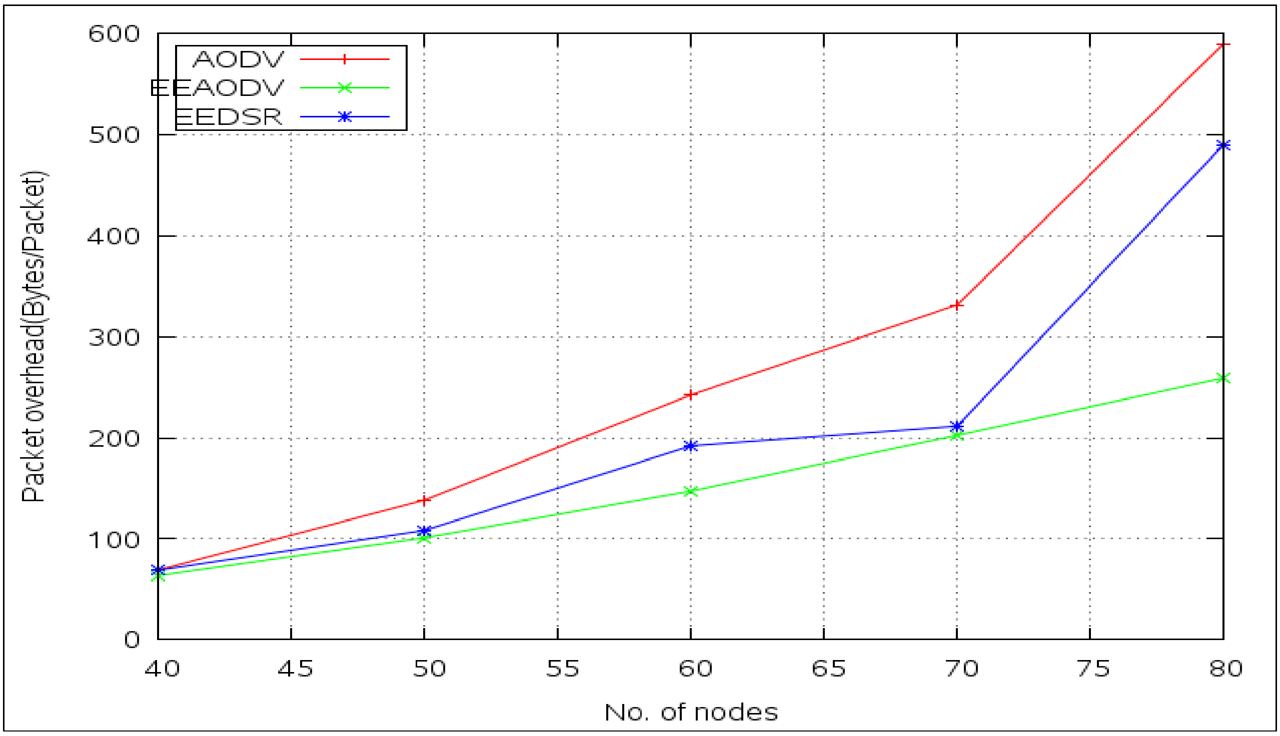

Fig. 4 Packet overhead of nodes

5.2 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.3 shows the result of packet overhead of network with respect to number of nodes varied in a given random area.

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 4. 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 .5 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.

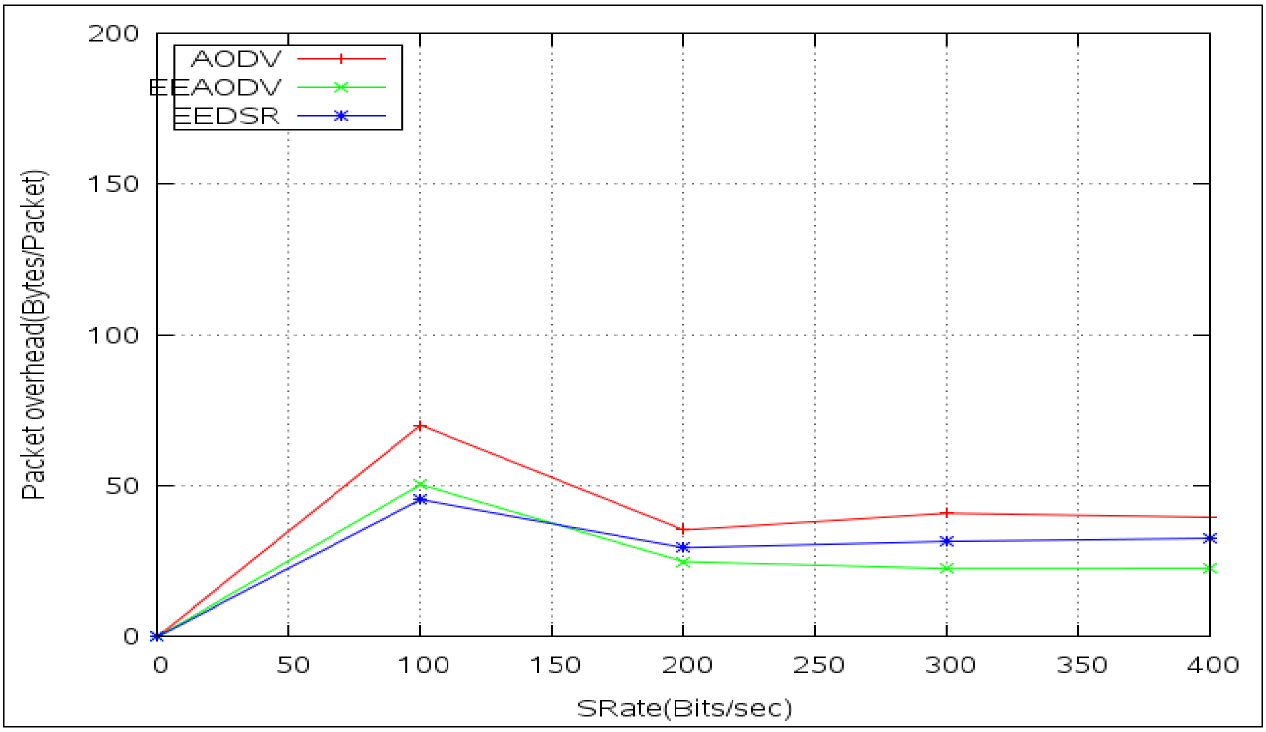

Fig.5 Packet overhead during data sending

5.3 Comparison of Protocols

Following table shows summary of performance metrics of AODV, EEAODV and EEDSR protocols which gives the optimum results to choose the best routing protocol.

Table 2 shows that EEADOV has better throughput than AODV. The basic route discovery phase remains same for both. EEDSR performs well as compared to both EEAODV and AODV. It also consumes 12% less energy than EEADOV and AODV. Hence it improves the network performance.

Sr No	Performance Metrics	AODV Protocol	EEAODV Protocol	EEDSR Protocol
1	Energy consumption of 80 nodes	2100 J	1500 J	1250 J
2	Energy Consumption at 30 bits/sec (Sending rate)	800 J	600 J	600 J
3	Throughput of 80 nodes	590 bits/sec	490 bits/sec	270bits/sec
4	Throughput at 100 bits/sec (Sending rate)	70 bits/sec	50 bits/sec	48bits/sec

Table 2 Comparative summary of protocols

VI. CONCLUSION

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.

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