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Comparative Analysis of MANET's Protocols for Energy Efficiency

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Abstract- Recently, remote expansion is getting popular day by day. Today, people sitting right across the continents are able to communicate with the help of Wireless technology. Mobile Ad Hoc Networks (MANETs) is an infrastructure-less network, which consists of various numbers of mobile nodes. In a MANET, the battery has always been an issue. So it is important for a protocol to be energy efficient so as to avoid network failures. A lot of work has been done to optimize AODV and make it energy efficient. It is important for us to choose the best algorithm to avoid battery problems in AODV. In this paper, we will study the comparative analysis between classic AODV, Randomized AODV and EE- AODV to figure out which one of the following is most efficient and has better performance than others. The simulation of the three protocols is done on NS- 2.

Index Items- MANETs; AODV; Randomized AODV; Energy efficient AODV; NS- 2; throughput; PDR; energy; delay.

1. INTRODUCTION

Mobile Ad Hoc networks (MANETs) are on-demand and are also considered as infrastructure less networks, which consists of nodes that self-organize and act as routers. Mobile nodes in MANETs are independent, therefore does not require any base station or a centralized control. Due to mobile nodes, MANETs are more unsafe than wired networks. MANET is more liable to malignant attacks because of the vulnerabilities like restricted physical security, changing topology, scalability and shortage of centralized management.

MANETs are decentralized which make them simple and flexible to deploy and therefore are used for many purposes. Applications that are provided by MANETs are as follows [1]:

1. Military Sector: The major usage of Ad hoc networks is in the military sector. MANET would enable the military to acquire the benefits of commonplace network technology to keep up data network among the troopers, vehicles, and military data headquarters. The essential approaches of MANET came from this field.
2. Commercial Sector: MANETs can be used in the remote regions or in the area of emergency for disaster relief efforts for example in a fire, earthquake or flood. Sensors automatically establish data network with is further useful for the rescuers and makes their job a little easier.
3. Low Level: Home networks are the appropriate low-level application where devices exchange information directly. MANETs will have many more applications in other civilian environments like cabs, boats and stadiums etc.
4. Data Networks: For MANETs, a commercial application has ubiquitous computing. After permitting computers to forward information for others, data networks are expanded far beyond the same reach of installed infrastructure. Networks are widely offered and easier to access.
5. Sensor Networks: In this technology, the network is composed of a large number of small sensors. These sensors are used to detect properties of a network, like pollution, temperature, toxins, pressure, etc. Each sensor must rely on each other in order to communicate the data to a central computer. Also, the sensors have limited computing capabilities.

Even though MANETs have such useful characteristics and applications, MANETs has some challenges to face. Sensors with limited power supply, quality of service, battery constraints, energy efficiency, security, network overhead, etc. are the challenges faced by MANETs. This paper compares the protocols to avoid the energy efficiency challenge for AODV in MANETs. It is necessary to have a protocol that is energy efficient so that we have increased the network lifetime and less delays in data packets.

2. ROUTING IN MANETs

A routing protocol, which is specifically designed for a network face several restrictions because of the mobility factor. Routing protocols of MANETs are divided into three categories, Proactive, Reactive and Hybrid routing protocols [2], as shown in figure 1.

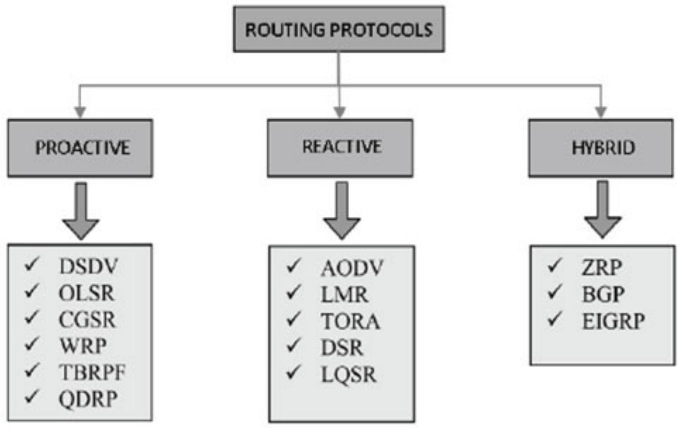

Fig. 1. Types of routing protocols [3].

2.1. *Proactive*

Proactive protocols also are referred to as "table-driven" routing protocols. In these protocols, each and every node involved in the routing maintains a table which contains all the information about the network topology. Hence, they have to consistently maintain and update the information which leads to more consumption of bandwidth [4]. Since these protocols maintain the information before it is needed, therefore, are called as Proactive. Some examples of Proactive routing protocols are Destination-Sequenced Distance Vector (DSDV), Fisheye State Routing (FSR), Global State Routing (GSR).

2.2. *Reactive*

Reactive protocols are also referred to as "On-demand" routing protocols. On-demand has a different approach from the table- driven. In this approach, when there is any need of path discovery, then only they are discovered. When there is no communication, there is no need to maintain the routing information [4]. The route - determination procedure is invoked by the route discovery when needed. This discovery procedure ends when the route is found or there is no route available. Various examples of Reactive routing protocols are Ad Hoc On-Demand Distance Vector (AODV), Dynamic Source Routing (DSR), Signal stability based adaptive Routing (SSR).

2.3. *Hybrid*

Based on certain conditions, Hybrid routing protocols are the combination of table- driven and On-demand routing protocols. Zone Routing Protocol (ZRP), is one of the examples of Hybrid routing protocols. In ZRP, internally we use proactive routing, but outside the zone, we use reactive routing [5]. Other examples of Hybrid routing protocols are, Cluster-Based Routing Protocol (CBRP), Border Gateway Protocol (BGP), Enhanced Interior Gateway Routing Protocol (EIGRP).

3. RELATED WORK

A decentralized category of the wireless network is known as MANET and in MANET, the nodes work on limited battery. It is impossible to change or recharge this battery, therefore the authors of [6] designed an energy efficient protocol, which considers the energy consumption of each node to increase the network lifetime. The authors of [6] purposed an MEP- AODV (Multipath Energy Efficient AODV) where the multipath selection is also considered with the energy consumption of the battery. When an intermediate node receives a RREQ, the intermediate node won't relay only RREQ immediately. Depending upon the remaining battery energy, the intermediate node will pass on the RREQ with a probability. After the destination receives the RREQ packet, it does not immediately forwards the RREP packet until the delay timer expires. The destination selects various paths from the collected paths as soon as the timer expires with sufficient battery energy. The results show that MEP-AODV is energy efficient to keep the lifetime of ad hoc networks maximized. In general, real time flows also need high QoS to manage bandwidth and data delay. In this regard, the author has purposed protocols as in [7][8].

As increasing the lifetime of the network, energy conservation is an issue that needs to be worked upon. The authors of [9] designed and implemented an energy-aware protocol, SEL- AODV for a secure wide area communication. SEL- AODV is based on AODV (Ad Hoc On-demand Distance Vector) and LEACH (Low Energy Adaptive Clustering Hierarchy). It uses Advance Encryption Standard (AES) to encrypt transmitted data. And as tested, network life time was increased with significant energy.

The authors of [10] proposed an algorithm to increase the network lifetime by using the remaining energy of each node known as MEL- AODV (Maximum Energy Level AODV). They calculate the costs of paths by the new energy model. The algorithm selects the path with maximum energy and minimum cost. MEL- AODV follows three assumptions, nodes with randomly distributed energy, from physical interface node's link-layer read the power information and could give it to the network layer and the signal attenuation is constant while two nodes communicate. Depending upon these considerations, the remaining energy level is being extracted when the nodes transmit or send packets. The protocol selects the link having higher energy for data transmission.

To enhance the energy of Ad Hoc On-Demand Distance Vector Routing Protocol, authors of [11] focus on energy usage of nodes and effort to increase network's lifetime. To attain this objective, they gave LEA-AODV (Local Energy Aware AODV). LEA-AODV decreases energy utilization and leads to draw out the battery life. In most on-interest routing protocols, the energy balance can be connected. At the time spent course revelation, LEA-AODV is calculated. In this paper, an energy model is utilized which makes sure that the node is educated about its energy level. Three parameters are taken into the count to initiate the algorithm: The fundamental Energy (Initial energy), The transmission power (tx Power) and Reception power (Rx Power).

Mostly the best solutions that we obtain are inspired by nature. Bee ad-hoc routing system is designed on the foraging principles of honey bees [12]. Throughout the network, the control packets are distributed and by that we observe that by sending them through various paths, minimum energy is consumed. The Bee ad hoc has four agents, as shown in figure 2: Packers, Scouts, foragers and Swarms. Packers reside within a node and forward the packets to foragers. Scouts have the task of exploring the path and discover new paths. Foragers deploy the data packets through the path discovered by scouts. Swarms are released and extract the foragers from the nodes. Below is the workflow for Bee ad-hoc.

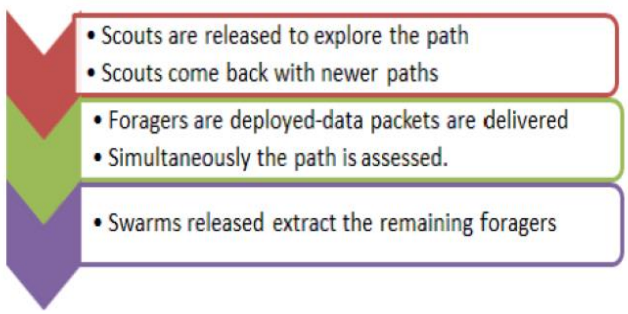

Fig. 2. Workflow in Bee Ad Hoc Routing protocol [12].

4. METHODOLOGY

Ad hoc networks are a dynamic and self-organized wireless network [13]. A group of wireless nodes is operated arbitrarily and freely to trade data without relying on a central base station or conventional infrastructure. In this MANET, network topology changes frequently as the nodes of the network move in irregular motion, also the nodes function as a router. Routing protocols are used in wired networks, because the dynamic nature of network topology, cannot be simply used.

4.1. *Ad Hoc On-demand Distance Vector routing protocol*

For populations of tens- thousands of mobile nodes in a mobile ad hoc network, AODV routing protocol is designed. AODV handles low, moderate, and relatively high mobility rates, also a variety of data traffic levels [14]. To reduce the distribution of control traffic and to eliminate overhead on data traffic, AODV has been designed in order to improve performance and scalability. AODV, a reactive routing protocol which performs route discovery process based on demand [15]. During the route discovery process, the protocol uses two control packets, Route Request (RREQ) and a Route Reply (RREP) to find and update the path. The next hop node information in the routing path is stored in the node's routing table those are participating in the routing path.

In AODV protocol, the process to establish the routing path is as follows [16]: assuming that a node SN wants send data to the node DN which make it the destination node but node SN has no information about node DN. Thus to make the connection, SN sends a route discovery packet, i.e. RREQ packet to the neighboring node as shown in figure 3. The RREQ packet carries the following routing information with it:

<source_addr, source_seq#, broadcast_id, dest_addr, dest_seq#, hop_count>

If the node receiving the RREQ has no information or is not node DN, it rebroadcasts the packet until it is received by the intermediate node or the destination node DN. As soon as node DN receives the RREQ packet, the reply to the packet is initiated. RREP packet is forwarded back to node S to establish the connection. RREP packet also carries the routing information as follows:

<source_addr, dest_addr, dest_seq#, hop_count, lifetime>

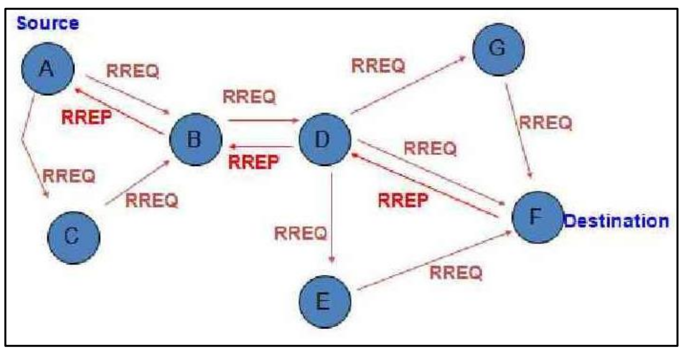

Fig. 3. AODV network layout [17]

The RREP packet is sent in the reverse via next hop node in order to reach node SN. The packet is forwarded until it reaches the node SN. In AODV protocol if by any means the routes are interrupted, a route maintenance mechanism is established. As a node moves out of the active communication path, the node releases a RERR packet. The RERR packet when reaches to the source node specifying the unreachable destination, source initiates new route discovery for the destination nodes. Figure 4 illustrates the AODV protocol mechanism.

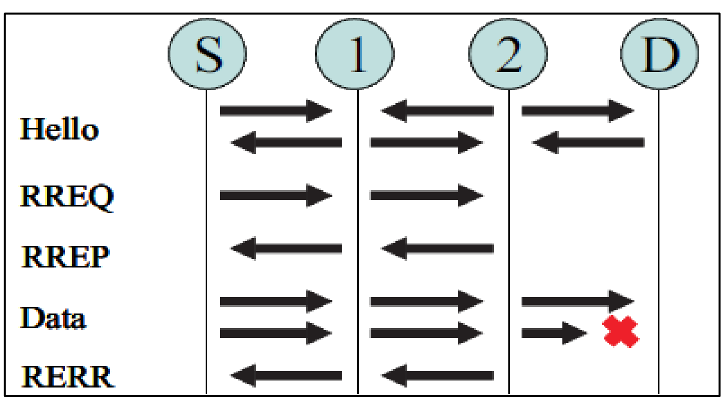

Fig. 4. Mechanism of AODV routing protocol [18]

4.2. *Randomized Energy based AODV routing protocol*

In a MANET, the nodes may switch their positions time to time. For deciding connectivity information of neighboring nodes, HELLO packets are used. By Link

Layer Detection mechanism, in AODV this connectivity information is already achieved. In the proposed algorithm [19], the nodes listen some already defined time intervals and count the number of HELLO packets. For $(i+1)^{th}$ node, more hello packets from the i^{th} node which means it will stay more in transmission range of $(i+1)^{th}$ node. After a definite time interval, $(i+1)^{th}$ node divides the total number of HELLO packets received by the total count. The value obtained will be the node in range factor which lies between 0 to the size of each interval.

In a MANET, nodes rely on battery. So to optimize this problem a routing protocol depending on energy criteria is designed. Each node during the route discovery process takes a decision whether to forward the RREQ packet or not and every node contains a certain energy. Now the new format for RREQ packet will contain a new value as transmission energy. Nodes lose some amount of energy after every transmission. Before forwarding the packet, every node in the network calculates the drop factor. The drop factor is calculated by dividing the remaining energy of the node by total energy. Drop factor ranges from 0 to 1. The packet is being forwarded when the random number generated by a node is greater than the drop factor. The aim of the algorithm is to reduce the unnecessary RREQ packets as much as we can. The throughput will be more for this algorithm as some RREQ packets are dropped. The algorithm for Randomized Energy based AODV is as follows:

- For every transmitting node, calculate the drop factor d
- Generate random number ranging from 0 to 1
- If (random value > d)
- Broadcast or forward the RREQ packet
- Else drop

4.3. *Energy efficient AODV routing protocol*

Energy efficient AODV is an improvement in the conventional AODV routing protocol. The authors of [20] purposed an energy model so as to increase the AODV network lifetime. Considering there is n number of nodes in a network. Now to calculate the energy factor of a node, we consider residual energy of the nodes at a particular instance. During packet transmission, a node consumes energy in transmitting, receive, sleep, idle and transition mode. We can calculate the remaining energy of a node n as:

$$E_{r(n)} = E_{i(n)} - E_{c(n)} \qquad \text{Eq. (1)}$$

Where, $E_{r(n)}$ is the remaining energy of node n, $E_{i(n)}$ is defined as the initial energy of node n, $E_{c(n)}$ is the energy consumed by the node n. Route discovery in EE- AODV is initiated by the source node when it needs to send a packet to the destination and source does not have knowledge the route to destination. RREQ and RREP are used to find the route to the destination is vice versa. At the source node when it wants to communicate to destination, it checks the route cache.

if (route from source to destination found)
{
preparation of route validation message that is to be sent to the destination and timer get started.
if (before the timer expires, acknowledgment arrives)
With existing route sends packets
else
NO UPDATE
}
else
No route available in the route cache and initiates the route discovery process. RREQ packets are broadcasted with the neighboring nodes. RREQ will be containing two additional information, i.e. Threshold value and hop count= 0.

Now, as the intermediate node receives the RREQ packet, it calculates the remaining energy level, which is compared to the threshold value.

if ($E_{r(n)}$> Threshold value)
{
the address is added to the header and hop count value is incremented by 1. Also, RREQ packets are rebroadcasted to neighboring nodes.
}
else
drop RREQ packet

As the RREQ packets are received by the destination node, it selects the path that has good energy levels. The destination node selects the path on the basis of hop count value. The path with less hop count would be selected. The RREP is replied by the destination to the source node.

5. STIMULATION AND RESULTS

We have used network simulator 2 (NS2) to carry out the simulations for AODV, Randomized AODV and Energy Efficient AODV routing protocol. Basic components like NS2, Tclcl, Tcl/Tk, OTcl, etc. are also included in the NS2 software package [21].To be specific, we will be using NS- 2.35 network simulator. It is an object-oriented, time driven simulator. It supports for simulation of TCP, multicast protocols and routing over wireless and wired networks.

5.1. *Stimulation Layouts*

Like a typical MANET deployment, the simulation of protocols has been carried out with the fixed positions of nodes where the number of nodes is ranging from 10 to 100. The simulation layout is being shown in figure 5.

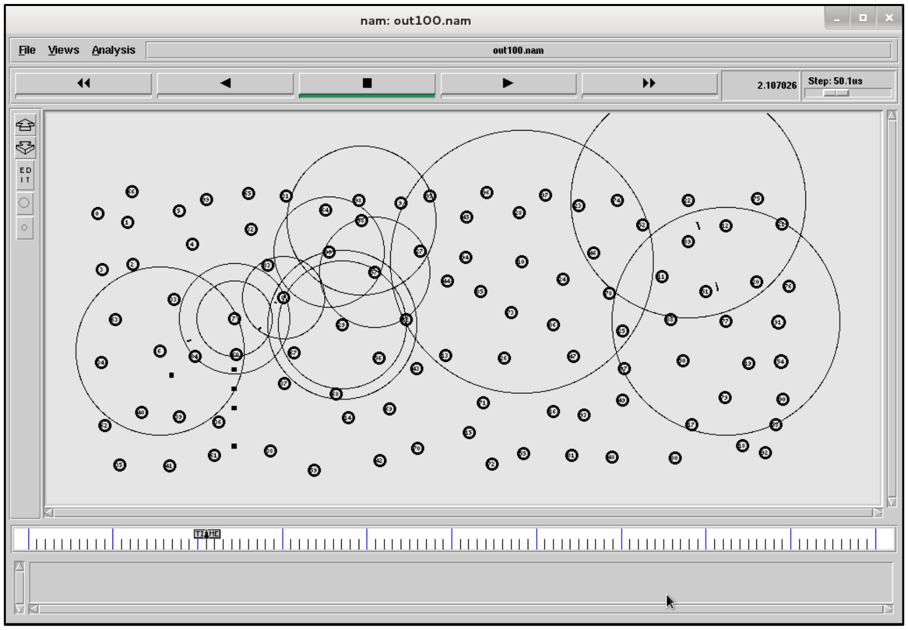

Fig. 5. - Simulation layout for 100 nodes

5.2. *Stimulation parameters*

Table 1 shows the parameters that are used for the simulation.

Table 1: Network parameters for simulation

Parameter	**Value**
Propagation	TwoRayGround
Channel	WirelessChannel
Terrain area	1267 X 612
MAC type	Mac/802_11
Interface queue type	Queue/DropTail/PriQueue
Antenna Model type	OmniAntenna
Application Traffic	CBR
Routing Protocols	AODV, R-AODV, EE-AODV
Number of nodes	10, 20, 30, 40, 50, 60, 70, 80, 90, 100
Initial Energy	100

5.3. *Results*

The performance comparison of AODV, R-AODV and EE- AODV routing protocols is being carried out after plotting graphs using xgraph, as shown in figure 6- 12.

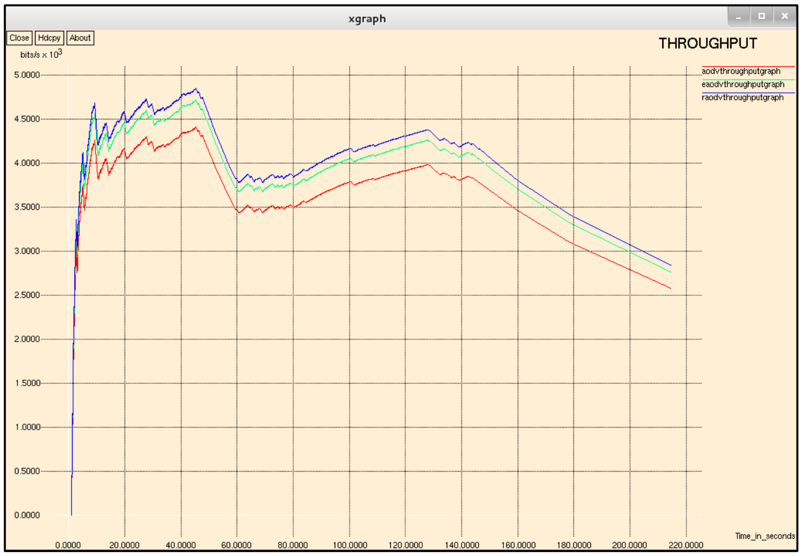

Fig. 6. Throughput

Figure- 6 shows the throughput comparison between AODV, R-AODV and EE- AODV. AODV routing protocol has the minimum throughput, whereas EE-AODV and R- AODV have better throughput than AODV. R- AODV gives better throughput than AODV.

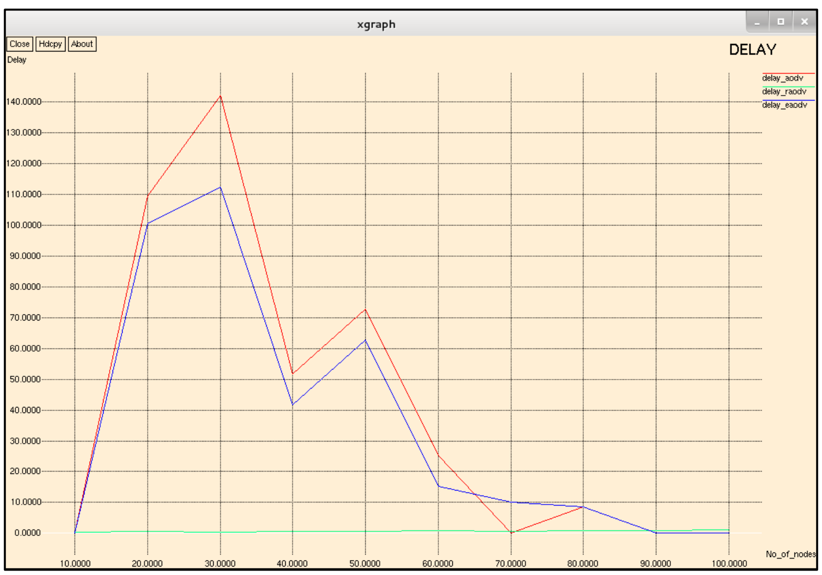

Fig. 7. Delay

Figure-7 shows the delay comparison between AODV, R-AODV and EE- AODV. AODV followed by EE-AODV, has the maximum delay when compared. R-AODV has the minimum delay.

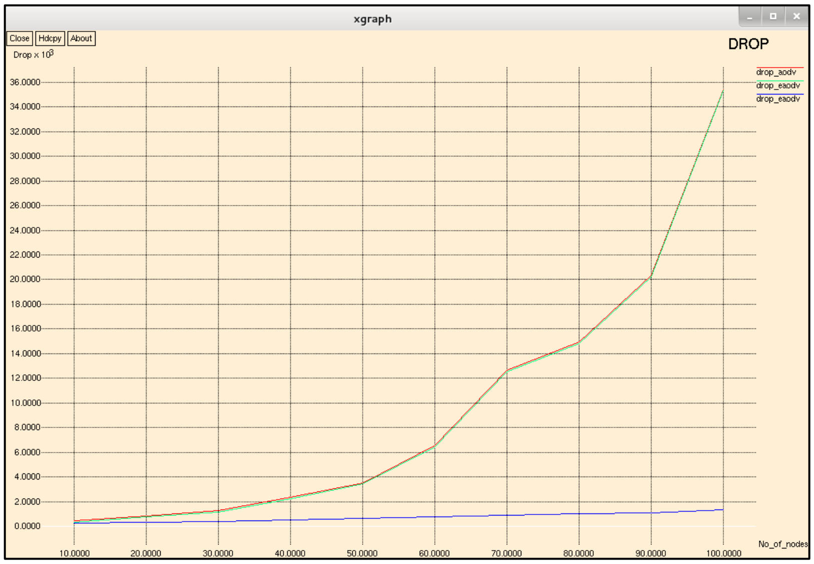

Fig. 8. Drop

Figure-8 shows the drop comparison between AODV, R-AODV and EE- AODV. AODV followed by EE-AODV, has the maximum drop when compared. R-AODV has the minimum drop value.

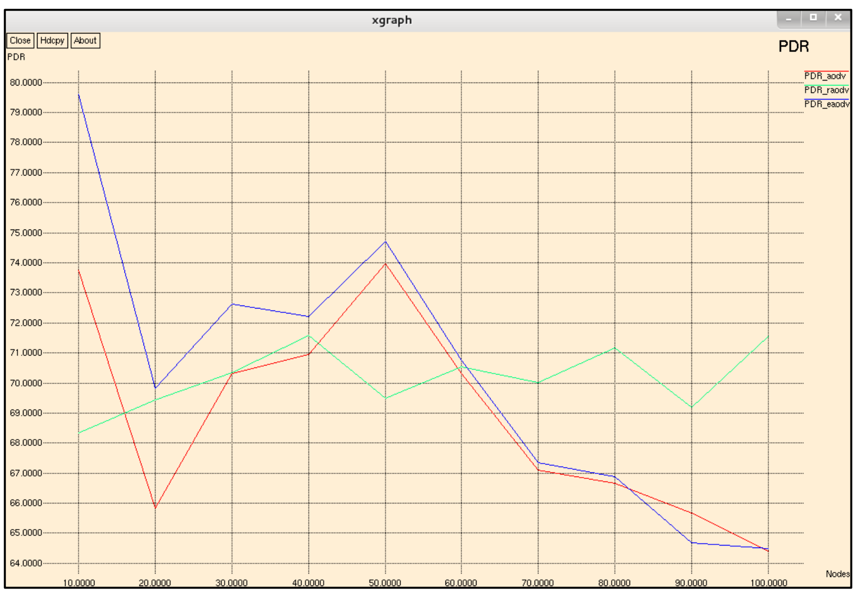

Fig. 9. Packet Delivery Ratio (PDR)

Figure-9 shows the PDR comparison between AODV, R-AODV and EE- AODV. AODV followed by EE-AODV, has the minimum packet delivery ratio, whereas, R- AODV has the maximum packet delivery ratio when compared.

From Figure 10- 12, we will be observing the node's energy for each routing protocol, i.e. AODV, R-AODV and EE-AODV. The graphs illustrate the energy of each node with time.

From the graphs shown, we observe that AODV has the least energy. Whereas, R-AODV has more energy as compared to AODV. But EE-AODV has the maximum energy as compared to other protocols.

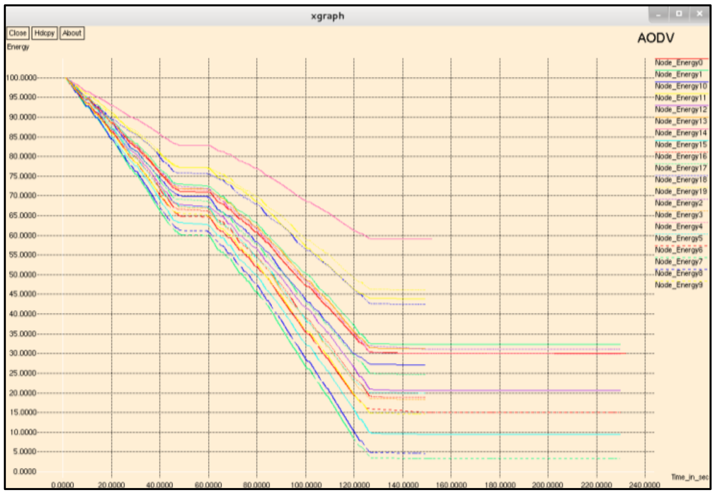

Fig. 10. Energy of nodes in AODV, where the number of nodes is 20

Fig. 11. - Energy of nodes in R-AODV, where the number of nodes is 20

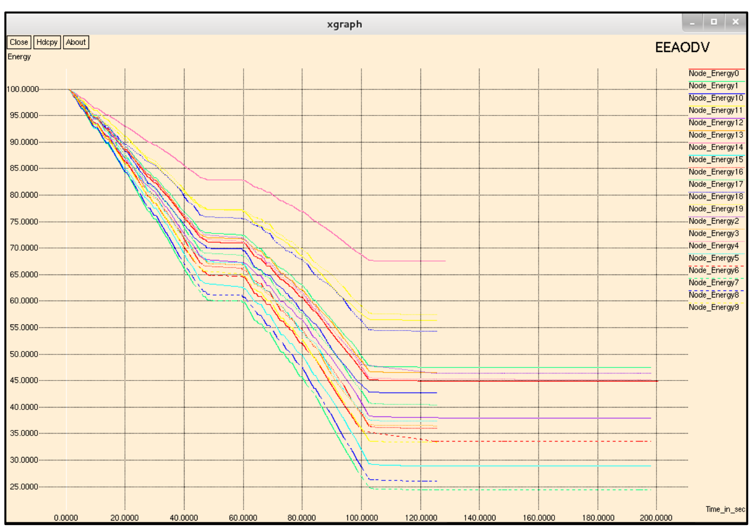

Fig. 12. Energy of nodes in EE-AODV, where the number of nodes is 20

6. CONCLUSION

This paper compares the three algorithms, i.e. AODV with the modified AODVs that are, R-AODV and EE-AODV. After the analysis, we conclude that R-AODV gives better throughput, delay, drop and PDR whereas for energy, EE-AODV gives better results. Scenarios where it is impossible to change or recharge the node's battery, we can use EE-AODV as it gives better energy results, plus better throughput, delay, PDR and drop than classic AODV. Whereas in the case where the battery can easily be charged or recharged we can use R-AODV for better performance in throughput, delay, PDR and drop, but as R-AODV gives better energy than classic AODV then we would prefer to use R-AODV in the place of classic AODV.

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