DEVELOPMENT OF AN ENHANCED AODV ENERGY MANAGEMENT MODEL AND LINK STABILITY IN MANET

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ABSTRACT: A mobile ad hoc network (MANET) nodes move arbitrarily and as a result the networks experience a rapid and unpredictable topology changes. The mobile nodes can receive and forward packets as router which leads to superfluous energy consumption. Routing being critical MANET makes this paper focus on one of the routing protocols i.e. Ad hoc On-Demand Distance Vector (AODV).To make the AODV more efficient with an enhanced route discovery procedure that will yield a reduction in the transmission delay that is caused due to instability of the path. Mobile nodes in MANET are battery dependant then suffers from limited energy level and as a result makes it difficult to recharge /replaced. Energy constraint in MANET lead to the development of an enhanced AODV (E-AODV) that reduces the variance in residual energy of the nodes, it also proposed a link stability parameter while selecting the path in order to increase the energy efficiency using a formulation for the link strength of the path that have the highest residual energy between the nodes. The enhanced AODV selects the path with the highest reliability and stability. Simulation was carried out using OPNET modeler for a different number of nodes in terms of delay, traffic sent and traffic received and the results shows that in any way the enhanced E-AODV outperforms the AODV.
KEYWORDS: AODV, E-AODV, OPNET riverbed, MANET.

I. INTRODUCTION

MANET stands for mobile ad hoc network. It is self configurable and decentralized wireless system which consists of free nodes. Theses nodes can be a mobile phone, laptop, personal digital assistance, mp3 player and personal computers as a result these nodes can move arbitrarily in every direction, and these nodes can be located in cars, airplanes and ships. These nodes can connect each other randomly and hence forming arbitrary topologies. Nodes communicate to each other and also forward packets of data to neighbor nodes as router. The ability of self configuration of these nodes makes them more suitable for urgently required network connection for example if a disaster hit areas where there Is no communication infrastructure. It is very important to have a quick communication infrastructure.

MANET is a quick remedy for any disaster situation, it is useful when dealing with wireless network in which some of the devices are part of the network only the duration of a communication session. The MANET working group within the internet engineering task force (IETF) works specifically on developing IP routing protocol. After huge research on MANET, still it does not have a complete form of internet based standards. The identification of experimental request for comments RFCs since 2003 is used. In these RFCs the questions are unanswered concerning the implementation or deployment of these routing protocols.

Routing means to choose a path. Routing in MANET means to choose a right and suitable path from source to destination. Routing terminology is used in different kinds of network such as telephony, electronic data networks and in the internet network. Routing protocols in mobile ad hoc network means that the mobile nodes will search for a route or path to connect to each and share the data packets. Protocols are the set of rules through which two or more devices (mobile, computers or electronic devices) can communicate to each other. In mobile ad hoc networking the routing is mostly done with the help of routing tables. These tables are kept in the memory cache of these mobile nodes. When routing process is going on, it route the data packets in different mechanism.

In MANET, protocols are classified into three proactive, reactive and hybrid routing protocols. Proactive routing protocols are routing protocols that continuously learn the topology of the network by exchanging topological information among the nodes. The reactive routing protocols proceed for establishing route to the destination only when the need arise. They do not need topological information of the network. Hybrid routing protocols often reactive or proactive feature of a particular routing protocol might not be enough instead a mixture of reactive and proactive might yield better solution. In recent days several hybrid protocols are also proposed. Based on the method of delivery of data packets from source to destination, classification of MANET routing protocols could be done as unicast and multicast routing protocols. The unicast routing protocols are those that consider sending information packets to a single destination from a single source. While multicast routing protocols that deliver information to a group of destinations simultaneously, using the most efficient strategy to deliver the messages over each link of the network only once, and creating copies when the links to the destination split. But multicast routing protocols for MANET use both multicast and unicast for data transmission.

II. RELATED WORKS

The Ad hoc On-Demand Distance Vector (AODV) algorithm enables dynamic, self-starting, multi hop routing between participating mobile nodes wishing to establish and maintain an ad hoc network. AODV allows mobile nodes to obtain routes quickly for new destinations, and does not require nodes to maintain routes to destinations that are not in active communication. AODV allows mobile nodes to respond to link breakages and changes in network topology in a timely manner. The operation of AODV is loop-free, and by avoiding the Bellman-For "counting to infinity" problem offers quick convergence when the ad hoc network topology changes (typically, when a node moves in the network). When links break, AODV causes the affected set of nodes to be notified so that they are able to invalidate the routes using the lost link. [PBD03].

[ACG15] enhanced existing AODV by considering energy constrained nature of especially intermediate nodes in MANET. Such nodes depend on a fixed battery life span from which they become inactive in the network. The authors termed the enhanced protocol OAODV, which defines the viability of a node to forward RREQ messages based on its remaining energy since energy is actually consumed while in the process of transmitting and receiving packets across the network. The authors considered varying network loads of 20, 30, 40 and 50 mobile nodes and considered the following metrics: throughput, packet delivery ratio, average energy consumed in a bid to compare classical AODV protocol to the proposed OAODV protocols. Simulation result obtained from NS2-2.35 reveal that in all cases OAODV outperforms AODV.

[JSS13] analyses the dynamic performance of classical AODV protocol in MANET using NS2-2.35 simulator. The authors considered two performance metrics namely packet delivery ratio and end to end delay with varying network load from 20, 60 to 100 nodes. Result obtained show that at 20 nodes end to end delay is least it increases with increase in network load to 60 and subsequently decrease at 100 nodes. For packet delivery ratio at its least when 60 nodes were studied, followed by the result obtained from 20 and 100 nodes respectively hence depicting the dynamicity of classical AODV protocol in MANET.

[DC11] designed intelligent AODV (I-AODV) routing protocol and compared its performance to conventional AODV using GloMosim simulator. I-AODV differs from conventional AODV especially in terms the way and manner in which route is discovered. In I-AODV the position and density of nodes around a reference node determine the probability value that would be assigned to such reference node to enable it forward RREQ packet much further in order to determine the desired route. Hence the reference node is considered to be situated in either sparsely populated area (i.e sparse region where the probability value is set at the highest value) or it is found in a density populated area (i.e dense region where the probability value is set to be low) this is done in a bid to minimize excessive and unwarranted packet collision otherwise obtained in the flooding technique employed by conventional AODV. Both protocols were compared using 25, 50, 100 and 150 mobile nodes under the following performance parameters: routing overhead, end to end delay, collision rate, control overhead, hop count and broadcast packets sent. In all metric considered I-AODV shows improvements to al greater extent than conventional AODV.

[K+11] studied and proposed an enhancement of the route maintenance phase of existing AODV routing protocol. The proposed protocol is designed in order to detect possible link break up front, such is reported to an upstream node so that a new route is re established before a route break. The link break is perceived from the following four (4) elements: received radio, overlap of routes battery and density of nodes. The proposed protocol termed AODV-BA was compared to existing AODV by simulation method using NS-2 simulator. Result obtained reveal that AODV-BA has less number of route breaks, increased packet arrival ratio, decreased end to end delay and a little increase in routing overhead, hence more effective than AODV.RREP loss makes the source node in MANET to reinitiate the entire process of route discovery. To avoid RREP loss through the use of existing AODV protocol.

[Y+14] designed implemented and analyzed efficient-AODV (E-AODV) routing protocol and evaluate their performance by simulation using NS-2.0. once the destination nodes receives the first RREQ message in E-AODV, the node generates TA-RREQ message that floods neighboring nodes within its transmission area. Once the source node receives the first TA-RREQ message, it begins packet delivery and later arriving TA-RREQ messages are saved for future use. With especially high mobility and density of nodes, E-AODV outperforms AODV while comparing their packet delivery fraction, throughput and end to end delay.

[SD13] the authors makes a survey on different energy efficient Algorithms based on AODV routing protocol, whereby they see the conventional approaches involve only finding the shortest path without taking energy into consideration, there after they makes a conclusion that by making a minor change in the route discovery process of AODV, routing can efficiently balance the energy consumption of the network

[A+14] enhanced the existing AODV by considering the route discovery mechanism. they tried to make the enhanced AODV reduce transmission delay which causes path instability, the authors simulate their result using NS2 by considering a varying network loads of 20, 40, 80 and 100 nodes in which they used packet ratio, packet loss and throughput as performance metrics. Simulation result obtained from NS2 reveal that in all cases EAODV outperforms AODV.

[AR15] designed an optimized energy routing protocol that tries to optimized energy and delay operation within a network path. The OEER protocol uses some strategies like co-operative MIMO technique and long haul transmission technique at the end they conclude by saying with the above mention techniques , it will be very much useful in future for the analysis of some energy efficient routing protocol.

[KN15] designed an energy path routing protocol for MANET that reduces variance in the energy of the nodes, the designed protocol select a path based on min-max formulation. The authors use NS2 as the simulator with varying nodes of 30, 50 and 60. The result obtained shows that in most cases the enhanced protocol performs better than the original AODV, DSR and DSDV.

[***18a] the authors makes a review by considering AODV with respect to link stability in MANET, they observed that in MANET nodes can join or leave the network due to link failure problem, whereby they proposed some techniques that can recover and reduced the chances of link failure in the network, but at last they recommend that among all the proposed techniques multipath routing is the most efficient and advanced technique for load balancing in energy efficient in MANET.

III. METHODOLOGY

In this paper both Analytical and simulation modeling were used, in the Analytical modeling power consumption estimation model was used and in the simulation OPNET riverbed Academic edition V.17.5 was used.

Analytical Modeling

Power consumption estimation model [Y+14] is a model used in Electric vehicle and the power consumption of the vehicle depends on the driving force, and the driving force is equal to the sum of four kinds of vehicle resistance which are air resistance (R_{air}), rolling resistance (R_{roll}), slope resistance (R_{slope}) and acceleration resistance (R_{acc}), the model formula is:

P- depends on $F_d = R_{air} + R_{roll} + R_{slope} + R_{acc}$

Based on the above model, the parameters used in the power consumption model is adopted and adapted, due to similarities among the parameters used on the model.

Then, to find the total energy consumed of a node we sum the amount of energy consumed at a node in sending, forwarding, dropping, and receiving packets over a hop. The total energy consumed is calculated as

$$E_{ci} = E_{s(ni)} + E_{f(ni)} + E_{d(ni)} + E_{r(ni)} \qquad (1)$$

Where Ec_i denotes the energy consumed at node i and

E_s = energy consumed in sending.

E_f = energy consuming in forwarding

E_d = energy consuming in dropping

E_r = energy consumed in receiving

We then subtract this consumed energy from the initial energy of the node to get the residual energy.

$$E_{residual} = E_{initial} - E_{ci}\ \text{consumed} \qquad (2)$$

To determine the ability of link j to forward packets from nodes A to B each with residual energy Eresidual 1 and Eresidual 2 respectively, then

$$\text{Link j's strength} = \frac{E_{residual\,1}}{E_{residual\,2}} \qquad (3)$$

Where $E_{residual1} < E_{residual2}$

If Eresidual1 = Eresidual2 ignore the path and choose another path

The link stability parameter is such that $0 \leq \lambda \leq 1$, for this analysis we assume λ=0.4

IV. WORKING OF ENHANCED AODV (E-AODV) ROUTING PROTOCOL

The E-AODV focuses on the routes with high energy levels and also avoids routes that have low energy levels. Like the original AODV , the E-AODV starts by checking if there is available route to destination else it will generate a RREQ message by broadcasting it to the intermediate nodes with the following fields Originator IP address, originator sequence number, Destination IP address, Destination sequence number, Hop count. Upon reaching the destination, the destination node will choose the path with a minimal number of hop count, after choosing the path, the destination node will check the residual energies of the chosen path wether if they have enough energy to send a packets of data back to source node. This is done by a link strength formular with respect to residual energy of the nodes

$$Link\ Strength = \frac{E_{residual\ 1}}{E_{residual\ 2}}$$

Where $E_{residual\ 1} < E_{residual\ 2}$
If $E_{residual\ 1} = E_{residual\ 2}$ the destination node will discard the path and choose another path based on the number of Hop count. Then a link stability parameter is proposed to compare the values of the residual energies of the nodes with the link stability value. The link stability has a range $0 \leq \lambda \leq 1$ and $\lambda = 0.4$. if all the values of the residual energies of the nodes are greater than or equals to the link stability λ, then the residual energies of the nodes in that path have the strength of delivering packets of data but if the residual energies of the nodes in a selected path are less than the link stability parameter value ,then that particular path does not have nodes that have enough strength to forward packet of data and the destination node will discard the path and choose another path based on the number of Hop count. After the destination node has finished checking the residual energies of the nodes and it founds out that all the residual energies are greater than the link stability parameter λ, then the destination node will update the destination sequence number and RREP route reply back by unicasting it on reverse path to the source node along with the following fields Destination IP Address, Destination sequence number, originator IP Address, and Life time. The link stability parameter is added in the IP packet header of the RREP.

V. ALGORITHIM FOR THE ENHANCED AODV ROUTING PROTOCOL

The enhanced AODV protocol E-AODV protocol find routes using the normal RREQ process whereby the source node being the originator of the RREQ message is responsible for the broadcast of the RREQ message to the intermediate nodes , upon reaching the destination, the destination node will check the residual energies of the nodes if they have enough energy to carry packets of data back to source, after checking the residual energies the destination node will choose the path that have nodes with residual energies greater than the link stability parameter and RREP back to the source node by Unicasting on reverse path.

STEP 1: Nodes (s) source node, If a route to destination is available start sending data Else generate a RREQ message that contains the following fields RREQ ID, Destination IP Address, Destination sequence number, The destination node will start checking the residual energies by dividing the residual energies between the nodes in the selected path Originator IP Address, Originator sequence number. Increment the sequence number by 1.

STEP 2: when the destination node obtains the route request RREQ, check the residual energies of the node for the selected path.

STEP 3:

$$\frac{E_{residual\ 1}}{E_{residual\ 2}}$$

Where $E_{residual\ 1} < E_{residual\ 2}$

STEP 4: If $E_{residual\ 1} = E_{residual\ 2}$, ignore the path and choose another path based on the number of hop count Else continue checking the residual energies of the nodes in the selected path

STEP 5:Check the residual energies of the nodes in the selected path by comparing the values of the residual energies with the link stability parameter $\lambda=0.4$

STEP 6: if the values of the residual energies are less than the link stability parameter λ discard the path and choose another path Else choose the path with nodes residual energies higher than the link stability parameter λ

STEP 7: Generate a RREP route reply message by unicasting it back to the source node on reverse path along with the following fields Destination IP Address, Destination sequence number, originator IP Address, and Lifetime.

STEP 8: when a RREP arrived back to the source node, then a connection will be established between the two nodes.

VI. SIMULATION AND RESULT

OPNET riverbed modeler V 17.5 Academic edition is used as a software for the simulation. OPNET provides multiple solutions for managing networks and applications e.g network operation, planning research and development and it is designed for modeling communication devices, technologies, protocols and to simulate the performance of these technologies. The simulation was tested for a different number of nodes and 5, 10 and 15number of nodes were used in this paper.

FIRST SCENARIO FOR 5 NODES

The simulation of the first scenario, 5 mobile nodes were used and one mobile workstation. The network size is 10 X 10 kilometers, after that IPV4 addressing was assigned to all nodes and a default network protocols that enable network to handshake and work properly were used. All the attributes were set in the last random mobility as MANET profile. Three parameters were used which include traffic sent, traffic received and Delay. The first scenario is shown below.

SECOND SCENARIO FOR 10 NODES

The simulation of the second scenario uses 10 mobile nodes and one mobility configuration. the network size is 10 X 10 kilometers, after that IPV4 addressing was assigned to all nodes and a default network protocol that enables network to hand shake and work properly. The mobility configuration was drag to the workspace all the attributes were set in the last random mobility as MANET profile. In this scenario, the number of the nodes was increased from 5 to 10 mobile nodes, this was done in order to check the behavior of these routing protocols, when the number of mobile nodes increase and how they react to different parameters such as delay, traffic sent and traffic received. The behaviors of these routing protocols are checked against the parameters with the increasing number of mobile nodes. The second scenario is shown below.

THIRD SCENARIO AT 15 NODES

The simulation of the third scenario uses 15 mobile nodes and one mobility configuration. the network size is 10 X 10 kilometers, after that IPV4 addressing was assigned to all nodes and a default network protocol that enables network to hand shake and work properly. The mobility configuration was drag to the workspace all the attributes were set in the last random mobility as MANET profile. In this scenario, the number of the nodes is increased from 10 to 15 mobile nodes, this was done in order to check the behavior of these routing protocols, when the number of mobile nodes increase and how they react to different parameters such as delay, traffic sent and traffic received. The behaviors of these routing protocols are checked against the parameters with the increasing number of mobile nodes. The third scenario is shown below.

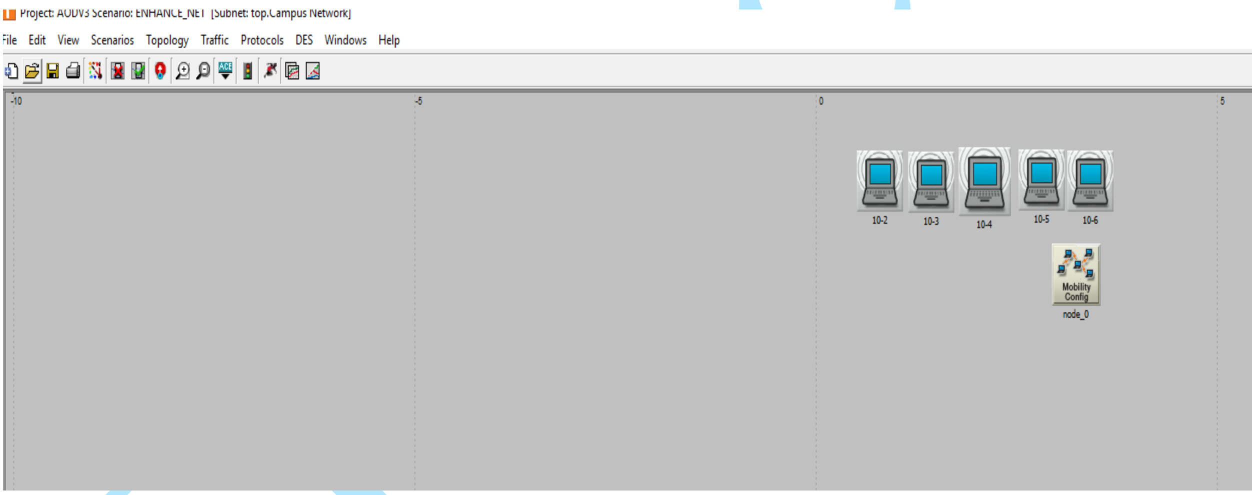

Fig 1. Scenario for 5 Nodes

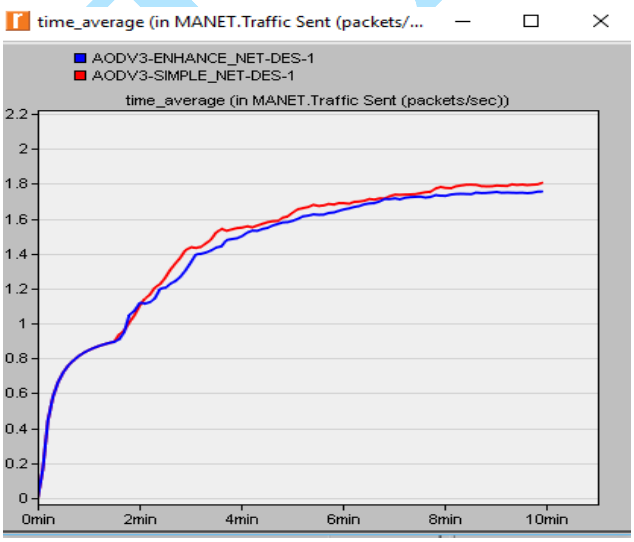

Fig 2. Traffic sent for 5 Nodes

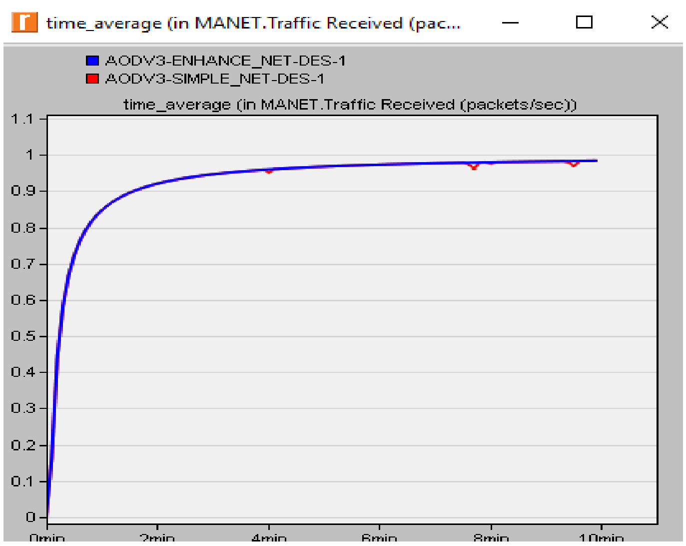

Fig 3. Traffic received for 5 Nodes

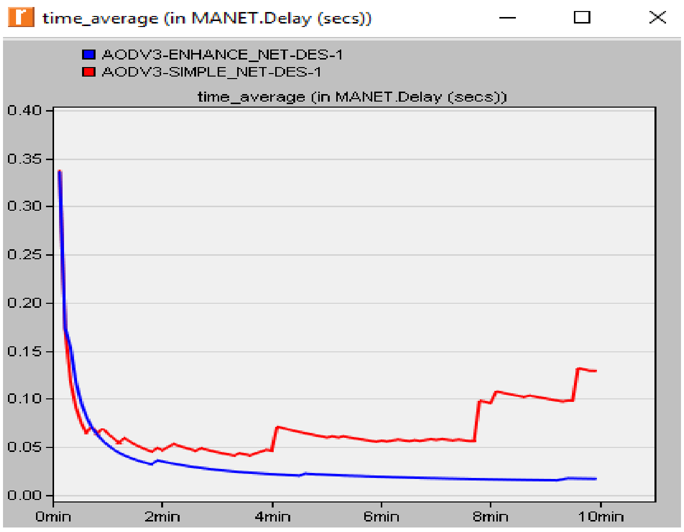

Fig 4. Delay for 5 Nodes

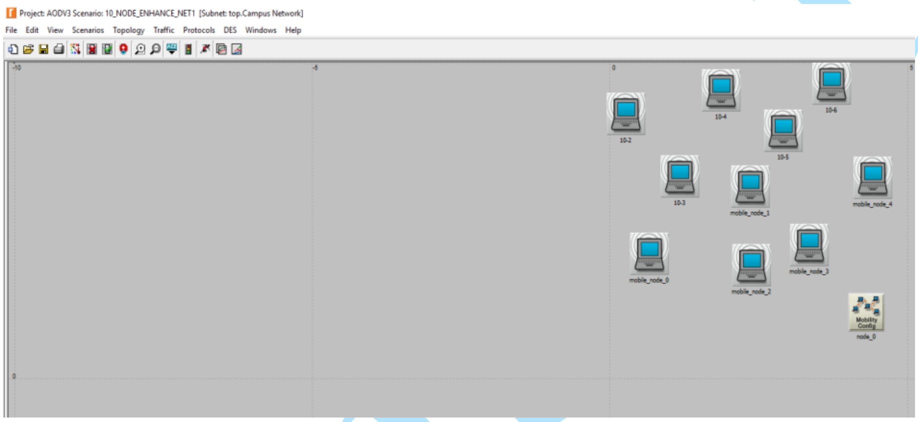

Fig 5. Scenario for 10 Nodes

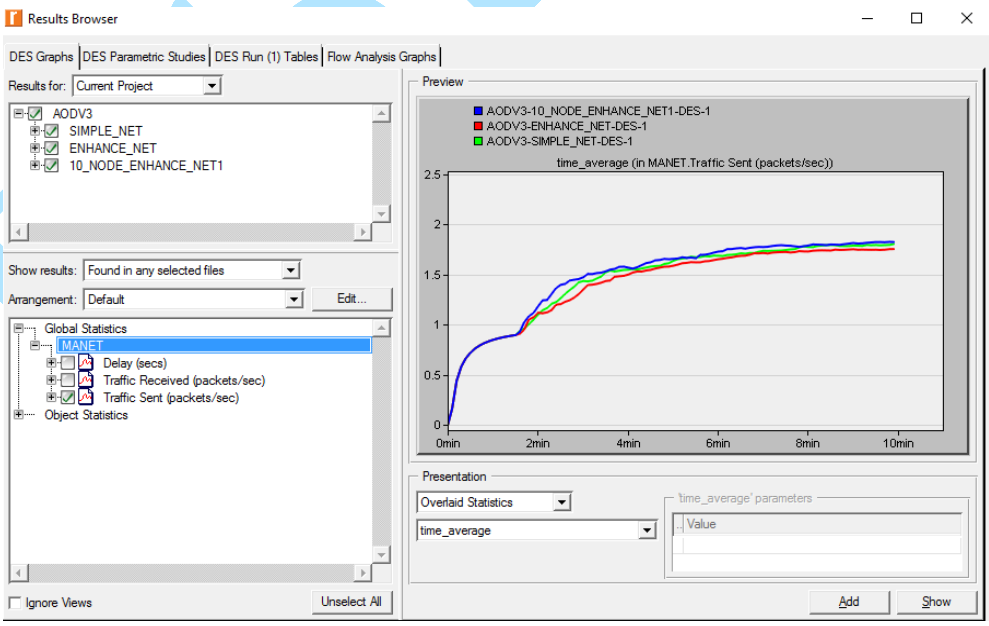

Fig 6. Traffic sent at 10 Nodes

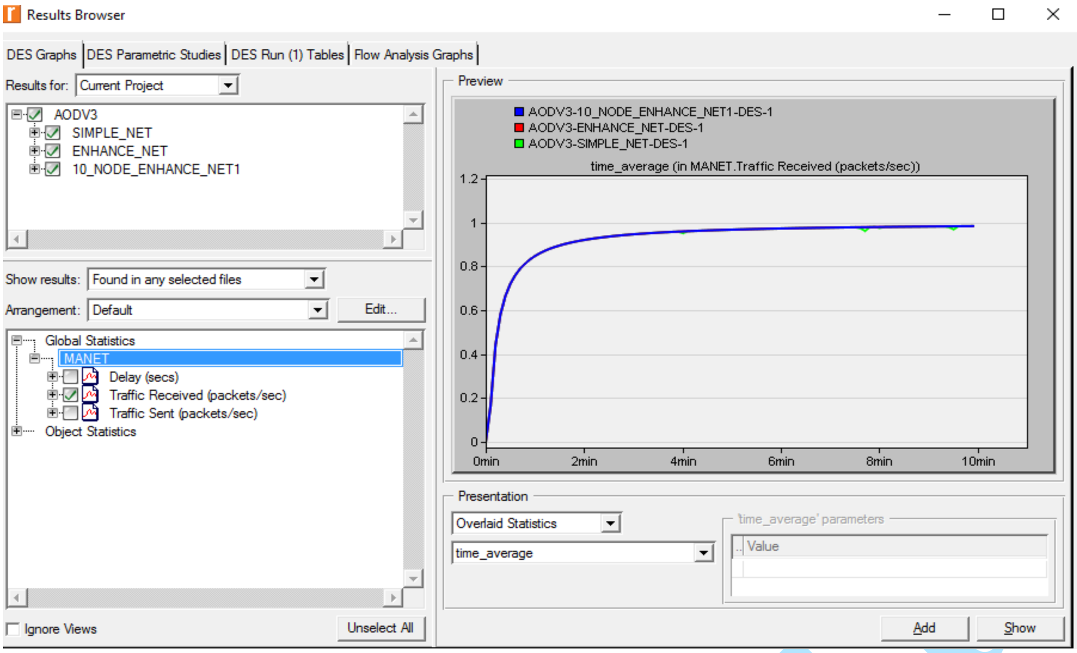

Fig 7. Traffic received at 10 Nodes

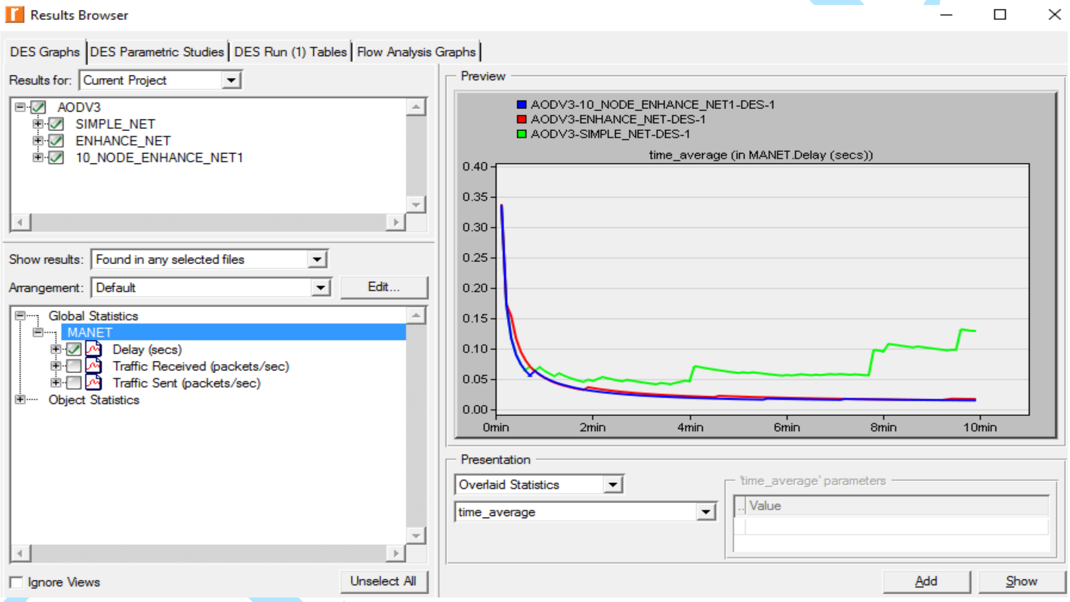

Fig 8. Delay at 10 Nodes

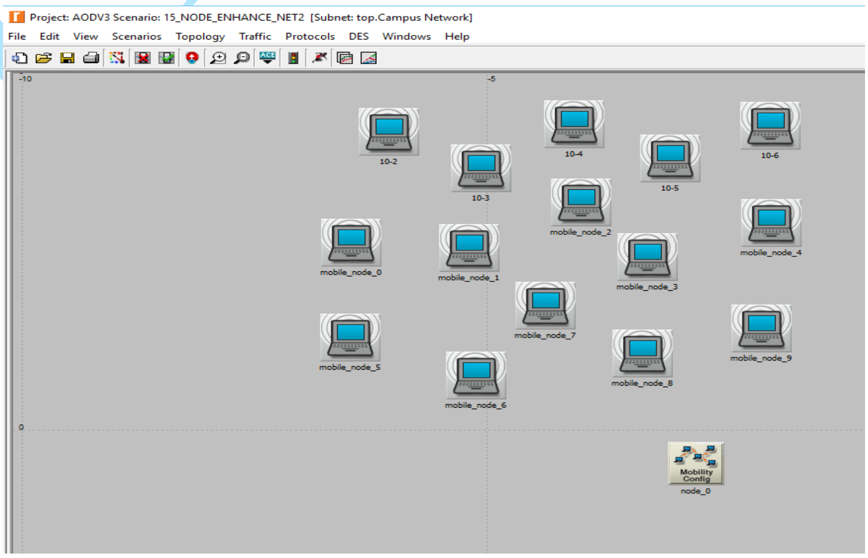

Fig 9. Scenario at 15 Nodes

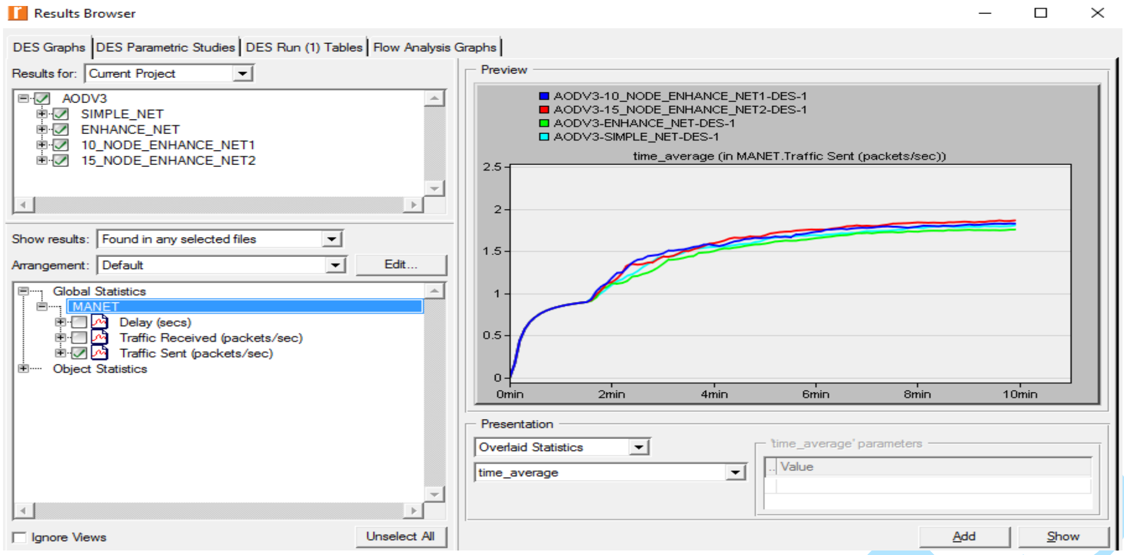

Fig 10. Traffic sent at 15 Nodes

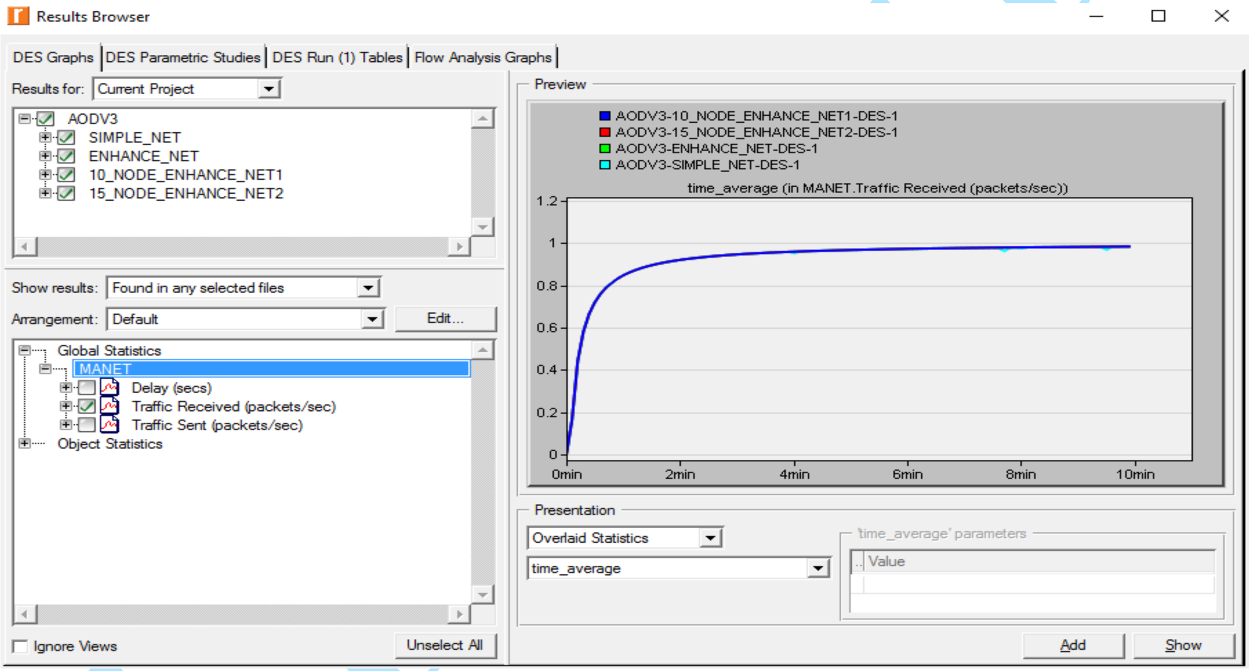

Fig 11. Traffic received at 15 Nodes

In figure 2 the graph is showing the traffic sent for 5 nodes which shows that AODV is better in traffic sent for 5 number of nodes with a value of 1.8/sec. In figure 3 the graph is showing the traffic received at 5 number of nodes where both AODV and E-AODV have same value after being run for 10min.In figure 4 the graph is showing the delay at 5 nodes.

In figure 6 the graph shows the Traffic sent at 10 nodes which shows that when the mobile nodes are 10 E-AODV has a highest value of 1.8/sec after 10 min. In figure 7 the graph shows the traffic received at 10 nodes, where E-AODV and AODV has almos the same value at 10 min. In figure 8 the graph shows the delay for 10 number of nodes where E-AODV almost drops down to 0.001. which significantly shows that more delay is reduced for E-AODV compared to AODV.

In figure 10 the graph shows the traffic sent at 15 number of nodes with the highest value of 1.8/sec compared to E-AODV at 10 nodes. The figure 11 shows the traffic received at 15 nodes is almost at the same point for all the protocols and figure 12 shows the delay for E-AODV at 15 nodes almost drops down to 0.001 which ultimately shows that as the number of the mobile nodes.

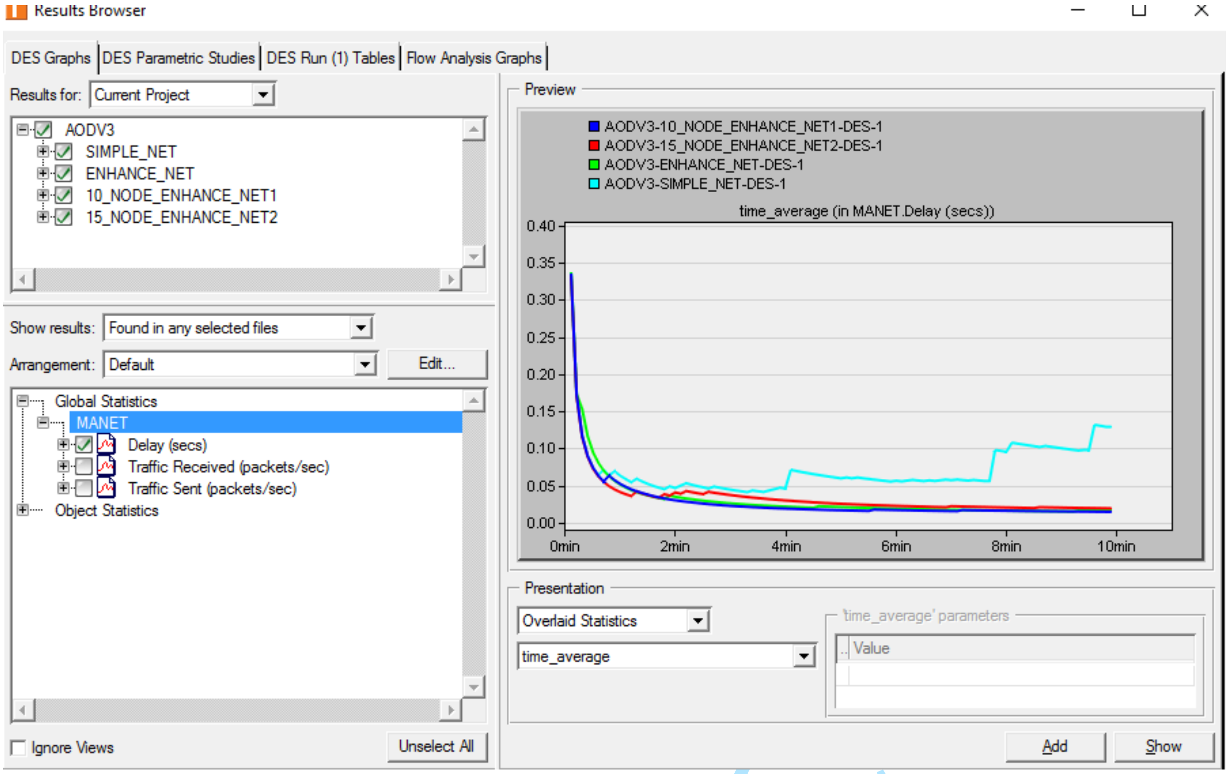

Fig 12. Delay at 15 Nodes

Table 1. Average values for traffic sent, traffic received and delay for aodv and e-aodv

Nodes	Parameters	Time	AODV	E-AODV
5	Traffic Sent (packets/sec) Traffic Received (packets/sec) Delay (sec)	10 min	1.8 0.98 0.13	1.78 0.98 0.03
10	Traffic Sent (Packets/sec) Traffic Received (packets/sec) Delay (sec)	10 min	1.60 1.99 0.13	1.80 1.99 0.02
15	Traffic Sent (packet/sec) Traffic Received (packet/sec) Delay(sec)	10 min	1.60 1.00 0.14	1.88 1.00 0.01

In figure 2 AODV performs better than E-AODV in terms of Traffic sent and in figure 3 Traffic received both AODV and E-AODV performs the same way but in figure 4 that is delay E-AODV performs better than AODV in which means that E-AODV is the best which has less delay at 5 number of mobile nodes. In figure 6, Traffic sent for 10 mobile nodes E-AODV performs better than AODV and in figure 7 Traffic received both AODV and E-AODV performs the same way, with a same value which shows that both AODV and E-AODV are good in traffic received at 10 mobile nodes. In figure 8 E-AODV has a less delay compared to AODV which almost shows that E-AODV at 10 mobile nodes has less delay compared to AODV. In figure 10 Traffic sent, E-AODV has better result compared to AODV, Figure 11 Traffic received both AODV and E-AODV performs the same way, in Figure 12 E-AODV performs better than AODV with a wider difference, E-AODV at 15 mobile nodes has less delay compared to AODV.

From the Above Table 1, E-AODV performs better in terms of delay, which shows that as a number of nodes increases more delay is reduced in E-AODV. In anyway E-AODV outperforms AODV

VII. CONCLUSION

The enhanced protocol E-AODV is aim at addressing some of the problem concerning AODV i.e energy, and energy is regarded as one of the most important constrain when it comes to MANET because MANET is about dealing with mobile nodes. Therefore a reliability factor is considered ,where by the enhanced AODV select path based on the path that has higher residual energies among the mobile nodes. The simulation study of this research shows the result of this two protocols i.e. AODV and E-AODV and the results shows that in any way E-AODV outperforms AODV.

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