Performance Improvement of MANET against Black hole Attack

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***Abstract*— Wireless mobile ad-hoc network consists of autonomous nodes that are self-managed. They have the ability to communicate with each node without static infrastructure. Ad-hoc networks have dynamic topology such that nodes can join or leave the network at any time. They are widely used in many applications such as military purpose, disaster area and so on. Security in mobile ad-hoc system is an important issue. One of the security attack in mobile ad-hoc network is the black hole attack. In black hole attack, the malicious nodes are injected into the network in which it absorbs all the data packets in itself. This malicious node drops all the traffic in the network. The attackers wind up all the information and drop it in the black hole attack. Many secure routing protocol have been introduced to avoid black hole attack inside the network. However they have various disadvantages. We propose a new protocol namely MAODV i.e.; Modified AODV which enhances the secure routing mechanism. It extends the AODV with following functionalities. By appending a verified field in RREP format and by sending the two RREP packets the black hole node is verified as valid or invalid. The invalid nodes are ignored from routing process. This Solution enhances the security and prevents the single and Multiple black hole attack. This simulation of the proposed protocol shows the significant improvement in the throughput, Energy consumption and End-to-End Delay.**

Keywords*— *MANET, Blackhole attack,AODV, MAODV

I. INTRODUCTION

Wireless Mobile ad hoc network is a multi hop wireless network with no static infrastructure. The ad hoc network is a dynamic topology in which any nodes can join and leave the network in any time. In the mobile ad hoc networks the node information are exchanged within the nodes with predefined infrastructures made spontaneously. The nodes within the respective radio range can communicate directly where as other nodes need to aid of the intermediate nodes for routing of the packets.

The ad hoc networks are used in many of the applications such as military communication, mobile conference, emergency rescue missions and so on. Ad hoc networks are suitable for the environment where it is not possible of providing a fixed infrastructure since MANET is a self organizing, infrastructure less and decentralized network.

The ad hoc networks have the advantages of low cost due to requiring of no expensive infrastructure. It has fast deployment and required less human intervention due to no involvement of cables. Ad hoc network are vulnerable to different kinds of attacks. Some of the attacks are denial of services, eaves dropping etc. In this paper we focus on Black hole attack which is the most possible attack in MANET.

Black hole is a kind of denial of service attacks where a malicious node will attract all the packets towards it by falsely advertising it has fresh route to the destination. Black hole attack falsely sends the RREP to the source node of having the new route to the destination. According to the AODV protocol the first path is considered to have the shortest fresh route to the destination from source. Malicious node pretend of having the shortest route to the destination and injects all the packets rather than forwarding it the destination. In route discovery process of AODV the intermediate nodes discovers the route to the destination. The black hole attacking node immediately sends the RREP with high sequence number without checking the routing table.

The aim of this paper is to avoid the single and multiple black hole attack in ad hoc network. Thus by modifying the AODV protocol the malicious nodes can be prevented from routing. A verified field is appended into the RREP format. Thereby sending the two RREP to the neighboring node the malicious node is verified and ignored. This MAODV protocol shows a significant improvement in the performance over black hole attack. In this proposed protocol it forwards only the valid route to the destination and ignores the malicious route from the whole routing process. The rest of the paper is organized as follows: section II summarizes the previous works which are against the black hole attack in MANET. The problem statement is described in section III. The basic concept of AODV and Black hole attack is discussed in section IV and section V respectively. The proposed system and Simulation experiment is described in Section VI and Section VII. It also deals with the Simulation Environment, Simulation results and analysis using network simulator in section VIII and conclusion is in section IX as follows.

II. RELATED WORK

In this section various related works are described. Several protocols which are proposed against black hole attack that are tried to improve the performance are discussed in this section. Mobile ad hoc network are easily threatened by many of the security attacks and black hole attack is one of the denial of service attack that causes serious impact on reactive routing protocols. However many works have been undertaken to mitigate the black hole attacks are summarized below.

In [9], the authors proposed a method to detect the black hole attack. By using the neighbouring nodes, the malicious nodes discards the packets. A default number to the nodes are assigned and checks whether they are changed or not by observing the transmitting behaviour of nodes. The value of the nodes are changed after a particular time. If the value of the node is below the certain threshold then the node is applied to the black hole list. This method has a disadvantage that it cannot be efficiently used in multiple black hole attacks.

In [16], the author introduced a new method of slightly altering the data routing information. The crosschecking of the table is made and the information of the existing and leave node are maintained. Thus only the valid nodes are available for the packets transmission.

In [3], the authors proposed a solution to evade the black hole attack in the network by SAODV method. In this method the intermediate node sends the next hop information and the route from source to destination is defined. The source node does not send the packets to other nodes immediately till it receives the next hop information and route reply. Further the path is determined as an initial path to send the packets. The password security and routing table updating have also been made in this technique. The secure routing information (SAODV) also includes key exchange, Data protection and secure routing. Each node should maintain a table with session key .However this method finds difficultly in managing the hop count or destination sequence number.

In [11] , the authors proposed a method to avoid the black hole attack in which neighbouring node receives the request packets first and initiates the routing process based on the replies. Once the source receives all the RREP, the node decides the node is a black hole node or not. By the view of the neighbouring nodes the honesty of the nodes are checked. However the disadvantage of this method is that the view of the neighbouring node is not trustworthy.

In [18] , the authors introduced a route reply caching algorithm to avoid the black hole nodes in the network. In this method it counts the route reply packets received by the source node. Then the source node decides the path to transmit the data packets to the destination without considering the first route reply. Since The malicious node immediately sends the route reply without checking the path in the routing table.

In [12], the author proposed a solution which enhances the AODV in which multiple black hole nodes are discovered. This method finds the multiple black hole attack nodes working in the co operative manner and discover the safe path to transmit the data packets. In this solution it is assumed that only the already authenticated nodes can participate in the routing. Each node in the routing is given a fidelity table in which each node provide reliability in the fidelity level. The node having 0 value is assumed to be malicious node.

In [6], the author introduced a new method for finding the single and the cooperative attack. It works well with mobile nodes in finding the malicious nodes in the network. It also finds the malicious node when the nodes are idle but the demerit is having more number of route requests.

III. PROBLEM STATEMENT

MANET is a infrastructure less network which can move while communicating. All the nodes act as router and can transmit the data packets. These networks are self healing and having self maintaining architecture. Ad hoc networks also have the challenges such as no fixed architecture, no fixed access point and irregular connectivity of the network. This network can easy adopt to the changes in the network and continues its communication with the other nodes.

Due to the dynamic changing characteristic of this network, it faces many security problems. One of the security problem is the black hole attack while using AODV protocol. In this black hole attack, the malicious node is injected into the network and all the packets are sent forward it. The data packets are dropped by malicious nodes that are send from source node to the destination node.

Secure way of transmitting packets from source is quite a challenging issue of the network. Less importance to security were given in the previous papers .The level of security should be improved for secure transmission of data. The problem occurs when a malicious node is injected into the network. The challenging in the ad hoc network are QOS, limited Resources, sufficient admission control, scalability, confidentiality and so on.

We propose a modified ad hoc on demand distance vector algorithm which provides an improved simulation performance against the black hole attack in the network. The malicious node inserted in to network is ignored from routing and it increases the rate of data transmission from source to destination. This proposed technique provides better security during the transmission of packets.

The protocol used in the proposed system reduces the problem in finding the malicious nodes and shows the significant improvement in Throughput, End to end delay and energy consumption.

IV. AD HOC ON DEMAND DISTANCE VECTOR

Ad hoc on demand distance vector algorithm (AODV) is a routing protocol which are most commonly used in ad hoc networks. In this routing mechanism when the source node decides to send the data packets to destination then the route is created. AODV is a on demand routing algorithm in which the routing path is created only when the source demands to send the packet. This AODV protocol chooses the direct or shortest path to the destination. The path from source to destination is active till all the packets are transmitted but the path is disconnected once all the packets are transmitted. In AODV protocol every node maintains its sequence number and it increases monotonically at every time the node notices the change in the neighbouring topology.

Each node in the AODV has their routing table to store the routing information of each node. The routing table can be used for both uni cast and multi caste routes. The routing table consists of the destination address, destination sequence number, next hop address and life time of the nodes. When a node wishes to send a data packet to the

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destination node then the source node checks the routing table to find if there is any path available path to the destination node. If the route is present then the source node sends the data packets to the next hop node or it initiates the route discovery process.

The AODV protocol consists of two main process. They are Route Discovery and Route Maintenance

In Route discovery process three types of messages are transmitted. They are
I. Route Request (RREQ)

II. Route Reply (RREP)

III. Route Error Message (RERR)

In the route discovery process the source node that decides to send the packet to the destination node broadcast the route request (RREQ) message to the neighbouring nodes. In general the RREQ message broadcast the request to find the route to the destination node. If the neighbouring node or destination node are finds the path then the neighbouring node sends the RREP message back. If the neighbouring node does not have path to the destination node, it forwards the RREQ to the neighbouring nodes. If any break in the link is established then RERR message is transmitted which indicates that the source node needs to re discover the path. This process is the route maintenance.

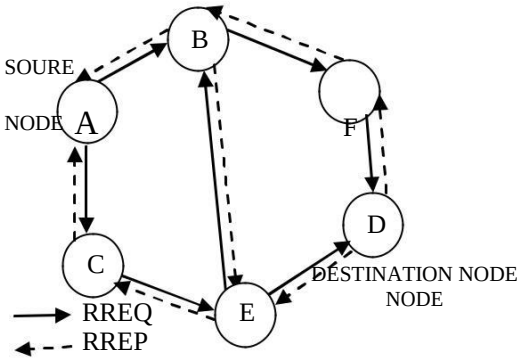

Fig.1. Route discovery and Route Maintenance of AODV

Fig. 1. shows the route discovery and route maintenance process. Node A is considered as the source node and Node D is considered as the destination node. When the source node decides to send the data packets to the destination then the source node A sends the RREQ message to the neighbouring nodes i.e., Node B, Node C. Once the RREQ reaches the destination node it reply back with the RREP to the source node (Node D, F,B,A). As per the AODV protocol the source node selects the shortest path route and the path with high sequence number to send the packets. By following the path (Node A,B,F,D)the source node send the packets to the destination.

V. BLACKHOLE ATTACK

Black hole attack is a denial of service attack in which a malicious node is added in the network and absorbs all the packets towards it rather than forwarding it. These types of attack generally occurs in the routing layer to prevent the transmission of packets. In black hole attack the malicious node sends the fake routing and demand all nodes to send the packets towards it.

There are single, Multiple and co operative black hole attack that occurs in to the network. A single black hole attack is that easily occurs in ad hoc network. More than one black hole attack that occurs in the network is known as Multiple black hole attack. When a group of malicious node combine to operate with each other to drop the data packets that flow from source node to destination node is known as co operative black hole attack.

During the Route discovery process the source node send the RREQ packet to the neighbouring node to find the path. If it reaches the destination node or the node having path to destination node send RREP. The black hole node sends that it has the fresh node to the destination. This malicious node sends the RREP without checking the route table and with the highest sequence number. According to original AODV it selects the first RREP is considered as the shortest path and the data packets are sent through that node. Malicious node will absorb all the packets forwarded towards it than forwarding it to the next neighbouring node.

Fig.2. shows that the malicious node is added to the network and drops all the packets towards it. In this Fig.2. the node c is considered as the black hole attack node.

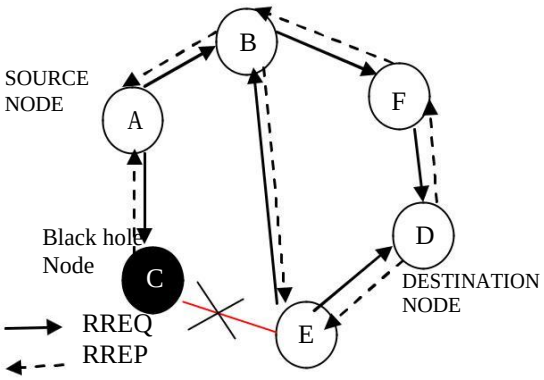

Figure.2. Black hole node in AODV

The node A decides to send RREQ towards the destination node D. After node C receives the RREQ, Malicious node sends the RREP without checking the routing table. The source node selects the path through node C since it shows that it has high sequence number and shorest route to destination. Source node sends all the packets towards node C. Black hole nodes drops all the packets transmitting towards it and reduces the performance of the network.This is the black hole node process and by using our modified AODV protocol the black hole nodes are avoided.

VI. PROPOSED SYSTEM

The proposed system describes the modified AODV protocol to prevent the black hole attack that frequently occurs in the mobile ad hoc system. In this modified AODV protocol, Verified field is appended in Route reply message format as shown in the Fig.3.

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TypeR	A	Reserved	Verified		Prefix size	Hop count
Destination IP Address						
Destination Sequence Number						
Originator Sequence Number						
Lifetime						

Figure .3. Modified AODV protocol

According to the AODV protocol when the source node decides to send data packets to the destination node then the source node sends the route request (RREQ) message to the neighbouring nodes. If the neighbouring node is the destination node or if it finds a path to the destination node, it sends the Route Reply (RREP) to the source node. By default the first fresh node with shortest route to the destination is chosen and the packet is transmitted over it. In our approach it is proposed that a modification is made in the RREP message format.

A verified field is appended in the route reply message format. By using this verified field the sequence number of the node are verified. Commonly Single sequence number is sent while sending RREP to the neighbouring node in the path but in our proposed system the intermediate node generate two RREP. The two RREP packets are generated from the same node for verification process. It is a confirmation process of second RREP packet is incremented by one. Therefore we have generated two sequence number, one with original sequence number and the other with the original sequence number + 1. By using the verified field the sequence numbers are verified and the malicious nodes are avoided. The VERIFIED field for both the RREP are set 0.

TABLE I. FIELDS OF RREP MESSAGE

Type	2
R	Repair flag; used for multicast.
A	Acknowledgment required
Reserved	Sent as 0; ignored on reception.
Verified	One bit specifies the packet Route Reply if it is valid or not as illustrated below: 0 refer to the invalid RREP 1 refer to the valid RREP
Prefix Size	If nonzero, the 5-bit Prefix Size specifies that the indicated next hop may be used for and nodes with the same routing prefix (as defined by the Prefix Size) as the requested destination.
Hop Count	The number of hops from the Originator IP Address to the Destination IP Address. For multicast route requests this indicates the number of hops to the multicast tree member sending the RREP
Destination IP Address	The IP address of the destination for which a Route is supplied.
Destination Sequence No.	The destination sequence number associated to the route.
Originator IP Address	The IP address of the node which originated the RREQ for which the route is supplied.
Lifetime	The time in milliseconds for which nodes receiving the RREP consider the route to be valid.

When the intermediate node receives the RREP it stores all the information about the RREP packet. The RREP message format is checked if 0 or 1 in the appended verified field.. If the verified field is set to 1,then the node is verified and it must be forwarded to the next node. In case the verified field is 0, it must be verified that the second route reply sequence number must be incremented by one with the first sequence number. If the verification is true then the verified field is set to 1 and it is forwarded to the next neighbouring node. If the verification process fails then the node is considered as the malicious node and the node is blocked from routing.

Generally the malicious node which causes the black hole attack will drop the packets that it receives. According to our proposed system the black hole nodes are avoided and there is a significant improvement in the performance of the network.

The below algorithm shows the Modified AODV protocol. This algorithm consists of four steps as follows.

Algorithm of MAODV

Step 1: Initialization Process

Start the route discovery phase with the source node S. Source node will broadcast the RREQ to its neighbours.

Step 2: Generation of RREPs

The destination node or the intermediate node generates two route reply packets with two different destination sequence number, the second one must be Incremented by one.

```
Send Reply (sequence number, // Destination Sequence Num
VERIFIED = 0, ); // Appended field
Send Reply( sequence number+1, // Destination Sequence Num
VERIFIED = 0, ); // Appended field
```

Step 3: Verification of RREPs

```
if ( intermediate node receives RREP )
{
if ( the first time the node receives RREP )
{
Store the IP address and seq. No. of the node;
}
if (the second time node receives RREP)
{
Store the IP address and seq. No. of the node;
}
```

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```
Check for valid RREP packet
{
if ( new RREP's seqno == old RREP's seqno + 1)
{
VERIFIED = 1; //( Mark RREP as valid)
}
}
if ( RREP is valid)
{
Forward RREP;
 }
Else
 {
VERIFIED = 0; //( Mark RREP as invalid)
}
if (RREP is invalid)
{
Ignore RREP
}
}
```

Step 4: Continue default process
The source node sends data to the destination node from the selected route reply packet.

VII. SIMULATION EXPERIMENT

A. SIMULATION ENVIRONMENT

We simulate our proposed system using NS-2 (Network Simulator), to eliminate the black hole attack in the network. Network simulator is based on the two languages, One is object oriented Simulator which is written in c++ language and then an object oriented extension of TCL (OTCL). To create various nodes, Topologies the simulator script begins by creating a instance of class by calling the method of class. In the physical and data link layer the IEEE 802.11 algorithm is used. The MAODV protocol is used in the network layer. The transmission packet size is considered as 2500 bytes and has the transmission rate of 1 Mbps. The terrain area is chosen to be 1000 x 1000 and has 100 of nodes with speed of 70bps. The source node, Destination node are given as the input by the user.

In Mobile ad hoc network the nodes are moved in random manner. The malicious nodes are also randomly distributed and they are placed anywhere in the network. These malicious node absorbs all the packets that are transmitted towards it. The data packets have the transmission range of 50m. Random way point model is used of having pause time of 10s.

B. PERFORMANCE METRICS

Protocols can be compared by evaluating the various performance of the network. The comparison of the AODV with the MAODV shows an significant improvement in the performance of MAODV. There are various Parameters, used to find the performance of the network and some of the parameters are used in our simulation results.

The malicious node which is added into network causes the impact on the ad hoc network. The performance metrics used for our simulation are Throughput, Average End to end delay and Energy consumption. A brief description on the metrics are given below:

1) THROUGHPUT

The throughput is defined as the average amount of data that is transmitted in the network in the given time. It is defined as the time taken for the average number of bits that are transmited from one end to other end. The total amount of received bit in the particular duration of time to destination is used for the calculation of throughput. The average throughput decreases when the speed of the node increases.

2) AVERAGE END TO END DELAY

The average end to end delay is defined as the delay of time between sending of data from CBR source and the corresponding CBR receiver. This delay also includes the delay time during buffering, processing, transmission time. This delay time is measured in milliseconds. Delay time for the black hole node decreases as the it sends reply packet without checking the routing table.

3) ENERGY CONSUMPTION

The energy consumption is the total amount of energy consumed by the nodes for the transmission in the network. It decreases with the black hole nodes in the network since there is drop of packets in the network. During the transmission of packets the energy consumption in the network increases.

TABLE II. SIMULATION PARAMETERS

PARAMETER	VALUE
COVERAGE AREA	1000 X 1000
NUMBER OF NODES	50-100
SIMULATION TIME	200s
TRANSMISSION RANGE	50m
MOBILITY MODEL	Random way point
DATA RATE	0.25
PACKET SIZE	512 bytes
ROUTING PROTOCOL	AODV/Modified-AODV
MOBILITY SPEED	0-30 m/s
NO. OF BLACKHOLE NODES	1 – 5
CONNECTION	5
TRAFFIC TYPE	UDP-CBR
PAUSE TIME	10S
TRANSMISSION SPEED	30-70 bps

To get the uniform and consistency output the same pattern is used throughout the experiment. The table II. Shows the simulation parameter of the experiment.

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VIII. SIMULATION RESULTS AND ANALYSIS

Fig.4. shows the input values used for the simulation. The number of nodes used in the transmission are selected. Total of 50 nodes are selected for transmission. The source node is selected as node 20 and the destination is node 29. The transmission packet size is chosen to be 2315 and the node strength is decided as 100 with the packet transmission rate of 40 bps.

Fig. 4. Input of simulation

In the Fig.5. shows nam window for the transmission of data packets from the Source node 20 and the destination node 29. The neighbouring node (Node 21-22-23-24-25-26-27-28) is chosen as the path by MAODV for the transmission of data packets from source to destination. The Fig.5. shows the transmission of data packets in the network without black hole nodes.

Fig.5. Transmission of Data packets from source to destination.

The Fig.6. shows the transmission of packets from source node 20 to destination node 29. Malicious nodes are added in the path of transmission. Node 12,14,18,24 are the black hole attacked node. During transmission the verification process is checked and the malicious node are located. These black hole nodes are forbidden from the route and selects the next neighbour for the transmission of packets. Thus all the packet are transmitted from the source to destination node. The figure shows the transmission of date from node 26 to 27.

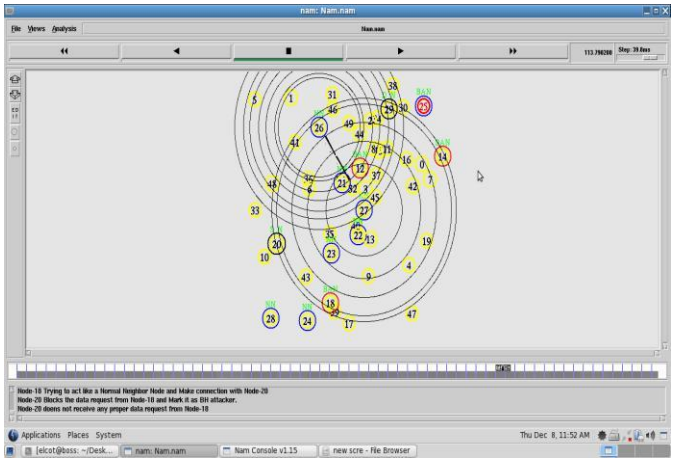

Fig.6. Black hole node present in the network

A. THROUGHPUT

It is the fraction of number of packets transmitted from source to destination at the particular amount of time. The throughput decreases with increase in the number of node due to more traffic. Traffic occurs during the route discovery process. The throughput of AODV and MAODV are compared and the simulation result is shown in figure.7. The result shows that the MAODV shows the improve in the performance comparatively with AODV Protocol. The throughput is calculated with the Multiple black hole nodes for both AODV and MAODV protocol. Thus the MAODV with multiple black hole node shows the improved performance compared to the AODV protocol.

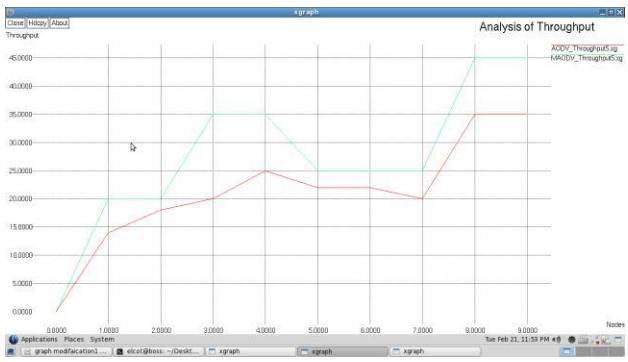

Fig.7. Analysis of throughput

B. ENERGY CONSUMPTION

The Energy consumption is the amount of energy consumed by the nodes for the transmission of packets from source to destination. Fig.8. shows the analysis of energy consumption of nodes for both MAODV protocol and AODV protocol with multiple black hole nodes. The analysis shows that the energy consumed by MAODV with multiple black hole is reduced compared to the AODV protocol with multiple black hole attack.

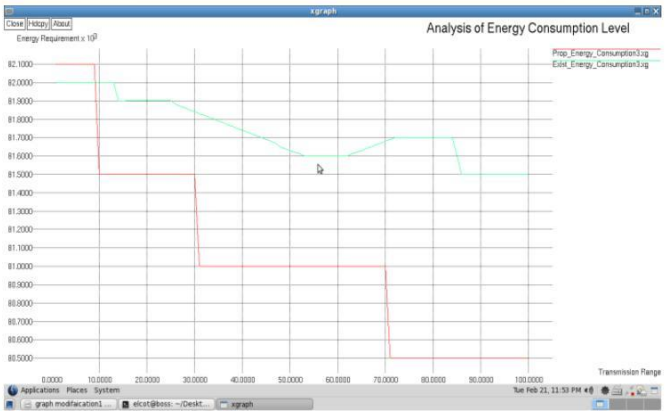

Fig.8. Analysis of Energy consumption

C. AVERAGE END TO END DELAY

The average end to end delay is the total time taken by the packets to move from one node to another. This delay time also includes the time for buffering of data, transmission time, generation of data. The figure .8. shows the delay for MAODV and AODV with multiple black hole nodes. The simulation result shows that little increase in end to end delay in MAODV compared with the AODV protocol. Since time laps during the verification process in modified AODV process. Thus in the analysis of end to end delay the AODV protocol with multiple AODV has decreased compared to MAODV with black hole nodes.

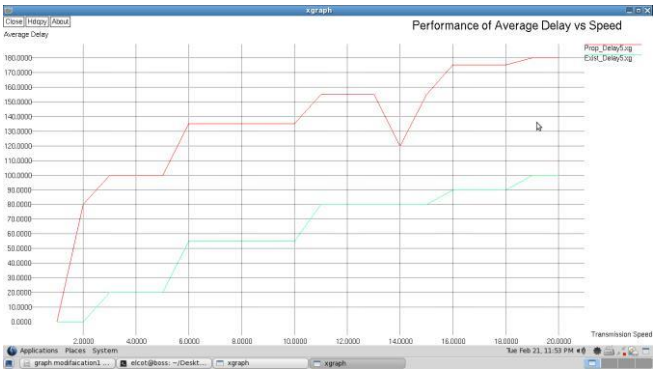

Fig.9. Analysis of Average End to End Delay

IX. CONCLUSION

In this paper, we have carried out a simulation based performance analysis of mobile nodes using modified AODV protocol against black hole attack. The simulation results show the comparison of AODV and MAODV protocol parameters. The various parameters used for the simulation are Throughput, Average end to end delay and Energy consumption. The simulation results of MAODV show the significant improvement in the performance compared with the AODV protocol. We conclude that our proposed MAODV protocol provides the improved performance with one or more malicious nodes.

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