A Solution for Detecting Black Hole Attack Using Improved DRI in MANET

Atifa Parveen[*1], Shish Ahmad[2] , Jameel and Ahmad[3]

ABSTRACT

Ad hoc Network is a self organized autonomous network that consists of mobile nodes which communicate with each other over wireless links. One of the common attacks in MANETs is the Black hole Attack, in which malicious node falsely claiming it to have the fresh and shortest path to the destination and then drops all the receiving packets. The black hole attack is one of the well-known security threats in wireless mobile adhoc networks. We proposed a mechanism to mitigate single black hole attack to discover a safe route to the destination by avoiding attacks. In this paper we proposed an approach for better analysis and improve security of AODV, which is one of the popular routing protocols for MANET. Our scheme is based on AODV protocol which is improved by deploying improved DRI table with additional check bit. The Simulation on NS2 is carried out and the proposed scheme has produced results that demonstrate the effectiveness of the mechanism in detection and elimination of the attack and improve network performance by reducing the packet dropping ratio in network. In this paper, We not only classify these proposals into single black hole attack but also analyze the categories of these solutions.

Keywords : *Mobile Ad hoc network, Black Hole Attack, DRI table, AODV, PDR, Network Simulator 2.*

1. INTRODUCTION

Wireless mobile ad hoc network (or simply MANET) is a self configuring network which is composed of several movable user equipment. These mobile nodes communicate with each other without any infrastructure, furthermore, all of the transmission links are established through wireless medium. According to the communication mode mentioned before. MANET is widely used in military purpose, disaster area, personal area network and so on.

A mobile ad hoc network (MANET) consists of a number of mobile nodes equipped with a transmitter and a receiver. There are number of vulnerability exist in MANET as lack of a fixed infrastructure, limited bandwidth, dynamic topology, resource constraints and especially limited battery lifetime and memory usage etc. The communication is difficult to organize due to frequent network topology changes. Routing and network management are done co operatively by the nodes thus forms multi hop architecture, where each node work as host as well as router that forward packets for other nodes that may not be within direct communication range. As, router the node will find the optimum path and manage the data delivery with the help of routing protocol scheme there are many different routing protocols have been devised for Ad Hoc networks and have mainly classified into three categories such as proactive (table driven) and reactive (On demand) and hybrid protocols. The proactive protocols maintain routing information about each node and information is updated throughout the network periodically or when topology changes. Each node requires to store and exchange routing

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information with other nodes p eriodically in order to have current routes to all des tination i.e. destination sequence distance vector (DSDV) Protocol. In reactive or source initiated on demand protocols, a node initiate a route discover y process throughout the network, only when it require to send packets, thus do not periodically update the routing information i.e. Ad hoc on demand distance vect or (AODV)Dynamic Source Routing (DSR) etc. Hybr id protocol makes use of both reactive and proactive approaches i.e. Zone Routing Protocol (ZRP). I n this paper we focus on AODV protocol which is one of the reactive routing protocols in MANETs. A ODV is an attractive protocol for most researchers because of its effectively adaptive nature in highly dynamic environment Ad hoc On Demand D istance Vector (AODV) routing protocol is sui table for both Unicast and Multicast routing. It is l oop-free and self-starting protocol, builds routing paths between the nodes only if demanded by the source node s.[1]

In this paper we have proposed a mechanism to identify multiple black hole n odes cooperating as a group in ad hoc network .the p roposed mechanism work with slightly modified AO DV protocol and make use of the data routing inform ation table (DRI) with 'check bit' in addition to cac hed and current routing table. We have find out misbeh avior nodes in mobile ad hoc environment, and also f ind secure route to the destination. And enhance the p erformance of network by eliminating cooperative bla ck hole attack.

The remaining paper is organiz ed as follows section II described related works, in section III AODV and behavior of cooperative black hole attack is discussed, section IV proposed mechanism is discussed for making MANET free from coopera tive black hole attack and also theoretical an alysis of the proposed scheme, simulation and results is carried out in section V, and finally conclusion and future direction are given in section VI.

2. RELATED WORK

Researchers have proposed vari ous techniques to prevent black hole attack in m obile Ad hoc network. Ramaswamy et al. [2] proposed a solution to defending against the cooperat ive black hole attacks. But no simulations or performa nce evaluations have been done. Hesiri. Weerasinghe and, Huirong. Fu [3] introduces the use of Data Rou ting Information DRI to keep track of past routing experience among mobile nodes in the network and cross-checking of RREP messages from intermediate nod es by source nodes. The main drawback of this tech nique is that mobile nodes have to maintain an extra database of past routing experiences in additio n to a routine work of maintaining their routing table. It is evident that maintaining past routing exper iences wastes memory space as well as consuming a s ignificant amount of processing time which contributes to slow communication. Mechanisms for securing the routing layer of a MANET by cryptograp hic techniques are proposed by Hu et al [4], Papa dimitratos, Hass [5]. Deng, Li and Agrawal [6] have suggested a mechanism of defence against a black hole attack on AODV routing protocol. In their proposed scheme, when the Route Reply packet is received from one of the intermediate nodes, anothe r Route Request is sent from the source node to the ne ighbour node of the intermediate node in the path. This is to check whether such a path really exists from the intermediate node to the destination node. While this scheme completely eliminates the black hole atta ck by a single attacker, it fails miserably in identify ing a cooperative black hole attack involving multiple mali cious nodes. Watchdog and Pathrater [7] use observat ion-based techniques to detect misbehaving nodes and report observed misbehaviour back to the source of the traffic. However, the scheme does not punish malicious nodes; instead, they are relieved of their packet forwarding burden. Nital mistr iy [8] has proposed an

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algorithm to counter black hole attack against the AODV routing protocol, using c mg_Rrep table and Mos_wait time. But, this metho d cannot tackle the problem of cooperative black hole attack. J. Sen et al. [9]. have presented a scheme for detection of malicious packet dropping node s in a MANET The mechanism is based on local mi sbehaviour detection and flooding of the detection information in a controlled manner in the netwo rk so that the malicious node is detected even if moves out a local neighbourhood. In [10], the au thors discuss a protocol viz. DPRAODV to counter the Black hole attacks. DPRAODV checks to find whether the RREP_Seq_No is higher than the threshold value. In this protocol, the threshold value is dynamically updated at every time interval. If the value of RREP_Seq_Nos found to be highe r than the threshold value, the node is suspected to be malicious and is added to a list of blacklisted nodes. It also sends an ALARM packet to its neighbours with information about the blacklisted node. Th us, the neighbour nodes know that RREP packets from the malicious node are to be discarded. That is, if any node receives the RREP packet, looks over the li st to check the source of the received message. If the reply is from the suspected node, the same is ignored. Thus, the protocol though successful, su ffers from the overhead of updating threshold value at every time Interval and generation of the ALARM packets. The routing overhead, as a result is highe r.

3. AD HOC ON-DEMAND DISTANCE VECTOR ROUTING

The Ad Hoc On-demand Distance Vector Routing (AODV) protocol is a reactive unicast routing protocol for mobile ad hoc net works. It operates in two phases namely route discovery and route maintenance AODV uses route discovery by broadcasting RREQ to all its neighboring nodes, Sequence numbers help in avoid ing the possibility of forwarding the same packet mor e than once. When a source node requires a route to a destination, it broadcasts a route request (RREQ) packet across the network. These broadcasted RREQ packet is received by each node present in the network during its travel each node increases the hop count by one. If an RREQ message with the same RREQ ID is received, the node simply reje cts the newly received RREQs.

An RREQ arrives at a node that possesses a current route to the destinati on. If an intermediate node has a route entry for the desired destination, it determines whether the route i s current by comparing the destination sequence numbe r in its own route entry to the destination sequence nu mber in the RREQ. If the RREQ's sequence number for the destination is greater than that recorded by the intermediate node, then intermediate node must no t use its recorded route to respond to the RREQ. Instead the intermediate node rebroadcasts the When the destination node or intermediate node that has fre sh enough route to the destination receive the RREQ message they create an RREP message and update the ir routing tables with accumulated hop count and the sequence number of the destination node. Afterwar ds the RREP message is uni casted to the source no de.

AODV Broadcasting a RREQ from source node and obtain a unicast RREP from destination node or intermediate node, Route maintenance is done by means of route error (RERR) pa ckets. RERR (Route Error) is initiated by the nod e upstream (closer to the source) of the break. It is pr opagated to all the affected destinations. RERR lists all t he nodes affected by the link failure When an intermedi ate node detects a link failure (via a link-layer feedback,.), it generates a RERR packet. The RERR propagates towards all traffic sources having a route via the failed link, and erases all broken routes on the way. A source upon receiving the RERR initiates a new route discovery if

it still needs the route. Apart from this route maintenance mechanism, AODV also has a timer-based mechanism to purge stale routes.

In AODV protocol, the routing table entry contains the following fields:

1. destination IP address,
2. destination sequencenumber
3. next-hop IP address,
4. hop count,
5. entry expiration time

3.1 Cooperative Black Hole Attack

A Black hole attack is kind of denial of service attack where a malicious node can attract all packets by falsely claiming a fresh ro ute to the destination and then absorbs them without forwarding them to the detonation. A black hole attack has to faces in the first face the malicious node exploit the Ad hoc routing protocol as AODV to advertise itself as having a valid route to a destination node in the second face the attacker node drops the interc epted packets without forwarding them.

Fake RREP messages from a malicious node contain the following paramete rs:

- Maximum destination sequence number " to make the route up to date.
- Single hop-count " to make a route with the shortest path.
- Life-long route " informs a ro ute will exist as long as the network.
- Destination IP address " addres s of the destination node copied from R REQ.
- Time-stamp "the time the RREP was generated

In case of cooperative black hole multiple black hole node are act in coordinat ion with each other the first black hole node B1fordward all the data to its partners node B2 and B2drop them instead of forwarding to destination. As In fig 1 source node SN wants to communicate with t he destination node DN, the source node SN broadcast the RREQ packet., each neighboring node update its routing table with an entry for the source n ode and checks if it is the destination node or whether it has current route to the destination node if an intermediate node does not have the current route to the destination node it updates the route request packet by increasing the hop count and floods the network with the route request to the destination node DN or any other intermediate node that has cur rent route to DN.

The destination Node DN or any intermediate node that has currently route to DN initiate a route reply in the reverse direction as shown in figure. The Source SN sends packet to the node which response first and discards others. In previous work author [14] propose solution to identify s ingle black hole attack. but When multiple black hole nodes are acting in coordination with each other f irst black hole BH1 refer to its partner BH2 as next hope, then as previous mechanism propose in [14], the source SN send further request (RREQ) to BH2 through a different route (SN, 2, 5, 6, BH2) other than via BH1.Node SN ask BH2 if he is having rou te to BH1 and route to DN. Because BH2 is co operating with BH1 its further reply is 'yes 'for bot h questions now as per solution in [11] node SN start sending packet assuming route (SN,1 ,BH1,BH2) is secur e but the packet are drop by node BH1.

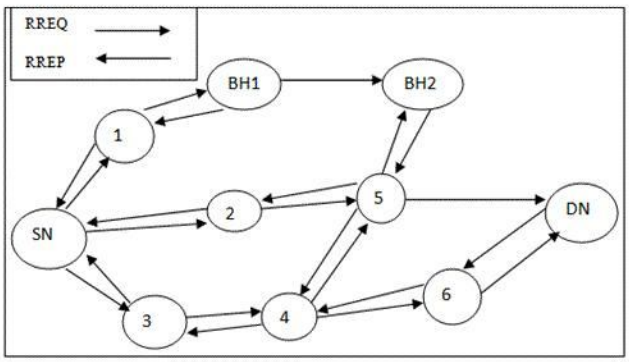

Fig.1. Shows RREQ and RREP Message Under Black Hole Attack

In the proposed solution we mo dify the working of source node using additiona function as RREP_TAB, a timer MOS_WAIT_TIME and a variable MALI_N. We also modified DRI (data routing table) by adding 'chec k bit 'with it. The source node accept and store all RREP s in the newly created table i.e. RREP_TAB until the time, MOS_WAIT_TIME which is half the value of RREP_WAIT_TIME i.e. the time for which source node waits for RREP control messages before regenerating RREQ control mess age.

Our security mechanism consist of four security procedures

(a) Neighborhood data collection and local malicious Node detection.
(b) Finding trusted node to destination and complete Elimination of black hole nodes.
(c) Establishing secure path to de stination.
(d) Blacklisting malicious Nodes.

(a) Neighborhood data collection and local malicious node detection

At this point each node store the data forwarding information about their neighbors in data routing information table (DRI) from [3].The DRI table for node'5' in table 1 maintain ro uting information of its neighbor nodes 2,BH2,4,6,8,DN. An entry '1' for a node under column ' from' implies that node 5 has forward data packet coming fro m that node and an entry '1' for a node under col umn 'through' implies that node 5 has forward data p acket to that node .thus entry for node 2 shows that node '5' has forward data packet coming from node '2' and node '5'has forward data packet to node '2' after a certain threshold time interval (which depend on the mobility of the network) each node iden tify its neighbor which does not interact for the purpse of data communication.

3.2 Local Anomaly Detection

The first security procedure i s invoked by a node when it identifies a node whic h has not interact for the purpose of data communication, and treated such node as the suspicious nodes by examining its DRI table as discussed above. The node that initiates the local anomaly detection proced ure is called as Initiator Node (IN) i.e.as parasol given in [5]. The node which successfully takes part in data com munication is known as cooperative node (CN). The IN first chooses a Cooperative Node (CN) in its neighborhood based on its DRI records and broadcasts a RREQ message to its 1-hop neighbors request ing for a route to the CN. In reply to this RREQ message the IN will receive a number of RREP messages from its neighboring nodes. It will cer tainly receive a RREP message from the Suspected Nodes (SNs). After receiving the RREP from the SNs the IN sends a probe packet to the CN through the SNs one by one to check the entire SNs. IN send probe packet at least two times to each SNs. After the time to live (TTL) value of each probe packet is over, the IN enquires the CN whether it has received the probe packet. If the reply to this q uery is affirmative, (i.e., the probe packet is received b y the CN) then the IN updates its DRI table by makin g an entry '1' under the column 'Check Bit' against the node ID of the SNs. However, if the probe packet is found not to reached the CN, then IN make an entry '0' under the column 'check bit'.

When each node i.e. node 5 che ck its neighbor. DN,4,6, BH2,2 he find that node BH2 ,6 ,DN are suspected nodes and node 2,5 a re trusted nodes for node 5 i.e. they securely rout e data from node 2 and node 4 with both column filled with 1, 1.

Table - 1
Shows DRI entry For Node 5.

Node id	from	through
BH2	0	0
2	1	1
4	1	1
6	0	0
DN	1	0

In Fig. 1, node 6 acts as the IN and initiates the local Anomaly detection proced ure for all SNs (First for node B1) and chooses Node 5 as the CN because Node 5 is the most reliable no de for node 6 as both the entries under columns 'Fro m' and 'Through' for Node 5 is '1'. Node 6 broadcasts a RREQ message to all its Neighbor nodes B1, B2, 4, 8, requesting them for a route to the CN, i. e., node 5 .in the example. After receiving a RREP From th e nodes, IN sends a PROB PACKET 1 first from node b1 to Node 5 after TTL value OF FIRST PROB PACKET is over then IN enquires node 5 whethe r it has Received the probe packet. ,if node 5 has n ot received the probe packet, then node 6 send another PROB PACKET 1 to node 5 through node B1 ag ain after TTL value it enquires node 5 whether he rec eive the packet from node 6 if PROB PACKET 1 is rec eived by CN then IN node makes an entry '1' und er the column 'Check Bit' in its DRI table correspo nding to the row of node B1 otherwise filled it with entry ' 0' .Similarly IN check all other neighboring node to fill their corresponding 'check bit.

Table - 2
Modified DRI table for node

Node id	From	Through	Check bit
BH2	0	0	0
2	1	1	1
4	1	1	1
6	0	0	0
DN	1	0	1

From here node 5 verify BH2, 6 as suspected node also reliable neighbors, 2, 4.

(b) Finding trusted node to destination and complete elimination of co operative black hole

Now through AODV protocol the source node (SN) send route request (RREQ) for the destination node (DN) now the source node (SN) will wait for a time MOST_WAIT_TIME to receive and store all route reply (RREP) coming from the destination node or from intermediate nodes(IN) and store all the request in its buffer in RREP_ TAB .Now source node demand there DRI tables and store them in buffer along with their 'check bits' now the source examine DRI table of all the nodes sequentially to find the trusted nodes Example If sourc e' SN' found 'RREP' comes from node BH2, 2, 4, 6 ,DN for reaching destination node 'DN'

Table - 3
RREP_TAB

Node RREP to destination	BH2	2	4	6	DN

Then source demand their respe ctive DRI table with check bit and find one trusted node (CN) to destination With the help of c heck bit .Now source node send prob packet TWO through remaining suspected node to that trusted node after TTL value of FIRST PROB PACKET is over s ource node SN make enquiry to trust node (CN) whether he received PROB. packet TWO. If packet not receive then source node send another PROB PACKET 2 to CN. if any one of two PROB PACKET is received we consider that node as another trusted node and source node mark an entry under check bit as '1'for that node but if the packet is not received source node treat them as '**black hole node'** and maintains the identity of such node as MALI_ NODE, so in future it can discard any control mes sages coming from that node.

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(c) Establish secure path to destination

The nodes whose check bit is ' 1' is considered as trusted node to the destinatio n now we check the DRI entry of such nodes to find an other trusted node in this way a secure path is esta blished from source to destination by eliminating mal icious nodes. According to figure 1 secure path SN, 2, 5, 4, 6, DN.

(d) Global alarm arising and blacklisting malicious node

The nodes which mark as '0 'under the column check bit and which do not res pond for probability packet is marked as black hole node. we store identity of such malicious node as MALI _node so that in future we can discard any cont rol message coming from that node and inform all the nodes in the network by generating alarm message to all the node in the network about malicious node . It also ensures that the identified malicious node is isolated so that it cannot use any network resources.

4. MANET

MANETs are vulnerable to vario us types of attack including passive attack as ea vesdropping, and active attack as interfering, impersonation and denial of service attack. Denials of ser vice (DOS) attacks which make network connectivity unav ailable to the intended user of the network Black hole attack is a kind of active Denial Of Service (DOS) attack. A black hole attack can be formed either by a single malicious node or by several nodes in collusi on. In black hole attack a malicious node tries to capt ure the path toward itself by falsely claiming large sequ ence number and smaller hop count to the destination and then drop all data packet instead of forwarding to the destination .In cooperative black hole attack set of node may be compromised in such a way that it may not be possible to detect their malicious behavior such node can generate new fake routing messages and provide incorrect link state information and thus increase packet dropping ratio in the n etwork.

5. SIMULATION AND RESULTS

We performed simulations in Ne twork Simulator NS-2. We have studied Differen t network scenarios to backup the defined model. Our Simulations run for 600(10 min approx.) second s. Nodes are placed on a flat plane of 1000m x 1000m. For radio propagation, the default Two R ay Ground model is used. 802.11 is used as Media Access Control protocol. Nodes mobilize to ra ndom points at random speed which is less than 10 me ter per second and are assumed to be always moving. Movements are randomized by program and save d in a scenario file for each simulation. Constant bit rate (CBR) generator is used to generate packets. D ata packet size is 512 bytes. User Data Program proto col is used in transport layer. The number of nodes is varied between 5, 25, and 50 nodes in which two of them are a resource saving node or a node which wi ll perform black hole attack. Data transfer rate bet ween nodes 512Kbps.

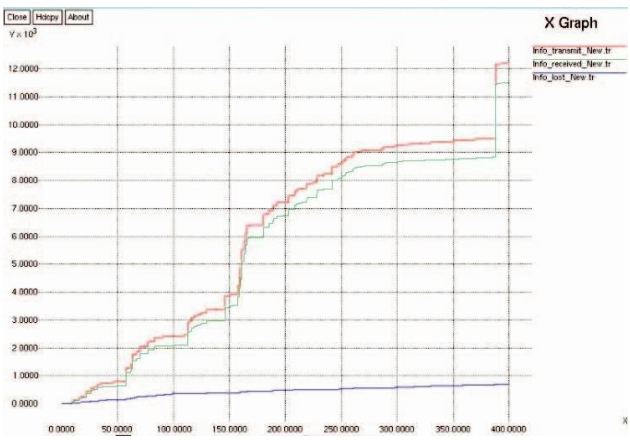

Fig. 2. Shows transmit, received lost packet and drop packet in route advertisement.

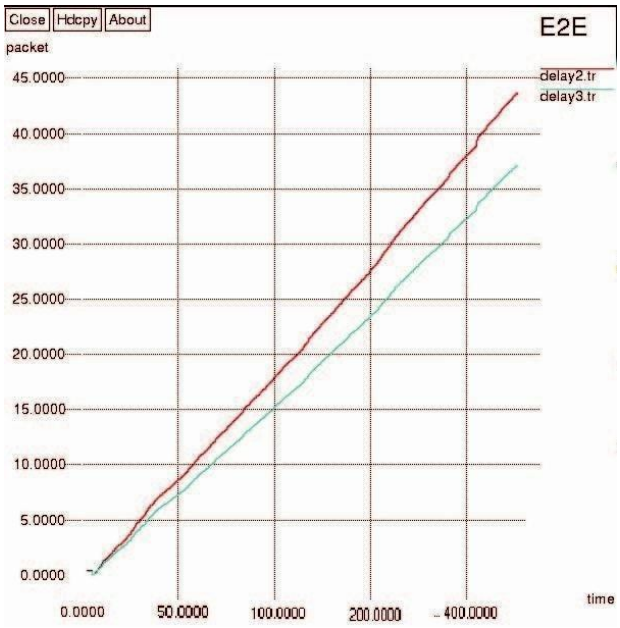

Fig.3. Shows the End to End delay.

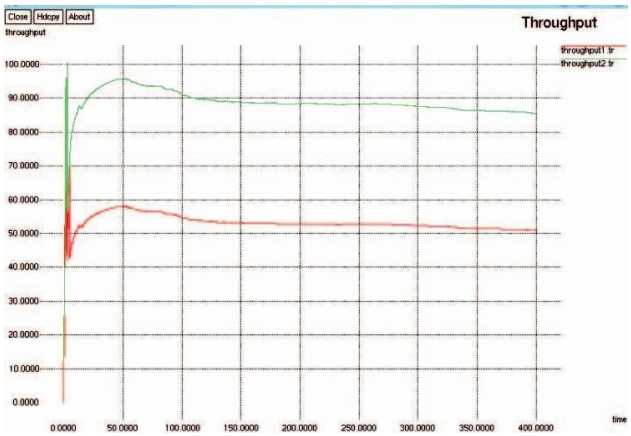

Fig.4. Shows the Throughput

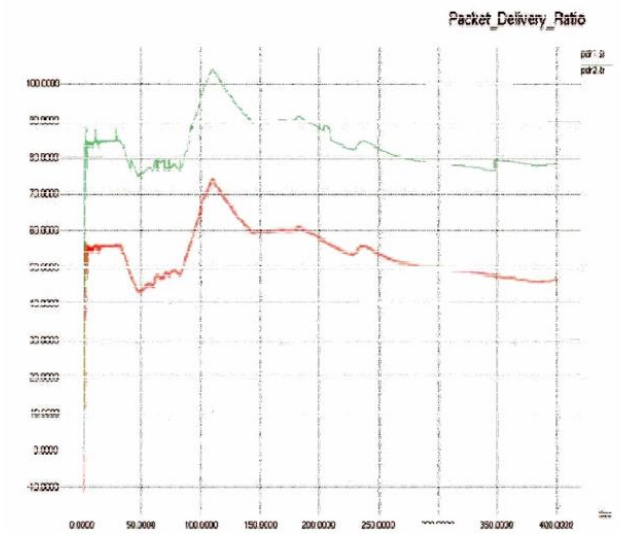

Fig.5. Shows the Packet Delivery Ratio

According to the above figure2 the transmission and retrieval of lost and drop packets in route advertisement has been minimiz ed.

In addition to this from the figurative analysis, according to figure 3 the rati o of end to end delay has decreased .AODV under black ho le attack exhibits decrement in the delivery ratio up to 46 % the proposed algorithm increases d elivery ratio up to 63% .thus we can see that there is an average improvement of 29%.

According to figure 4 the throughput of our proposed mechanism is as high as compared to normal AODV with black hole attack .F urther from figure 5 we can conclude that the packet delivery ratio is increase, that means the deliv ery ratio of eliminated black hole scenario goes up af ter detecting black hole it goes around 90% in average when the black hole present the delivery ratio is under 70%. It is observed from simulation that our propo sed mechanism perform better result analysis as compared to the normal AODV protocol under black hole attack.

6. CONCLUSION AND FUTURE W ORK

Black hole attack is one of the major security challenges for MANETs .We have proposed a feasible solution for it in the AODV protocol. The proposed solution c an be appl ied to identify multiple black hole nodes cooperating with each other in a MANET; and discover secure pat hs from source to destination by avoiding multiple black hole nodes acting in cooperation. Also, w e showed that the effect of packet delivery ratio and t hroughput with respect to the variable node mobility. There is reduction in the Packet Delivery Ratio and throughput. In Black hole attack all net work traffics are redirected to a specific node or from the malicious node causing serious damage to networks and nodes as shown in the result of the simulation. The detection of malicious node in ad hoc networks is still considered to be a

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challenging task. Simulation s hows that AODV with our mechanism gave comparatively better performances as compared to DSR. As a future scope of work, the proposed se curity mechanism may be extended to detect other ma licious nodes as gray hole and wormhole attacks in M ANETs.

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