Effects of Black Hole Attack on Different Routing Protocols of MANET under IPv6

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ABSTRACT

Mobile Ad Hoc Network is short lived autonomous network which is formed by collection of mobile nodes connected through wireless links without any fixed infrastructure support. Due to its structure mobile ad hoc network prone to various types of security attacks. Black Hole Attack is one of them security attack. The data packets in black hole attack routed towards node which not actually exists in network it receive and drop all data packets.IPv6 is internet protocol which gains popularity over IPv4 with its certain features like more address space, multicasting, and multihoming.IPv6 is more secure as compared to IPv4. Thus it is essential to study the effects black hole attack of mobile ad hoc network routing protocols in presence of IPv6. This research paper study the effects of black hole attack on AODV, DSR, GRP and OLSR under IPv6 on the basis of certain parameters like end-to-end delay, network load and throughput. For collecting and analyzing results OPNET 14.5 is used. On the basis of observation it found GRP performs better as compared to other routing protocols under black hole attack.

Keywords

MANET, AODV, DSR, GRP, OLSR, OPNET

1. Introduction

The present era is era of wireless technology. Wireless technology is growing day by day because it is affordable, easily available, easy to use, easy to deploy. Due to advancement in wireless technology wireless networks attain the attention of researchers. Wireless network is a type of network which is formed by without any kind of wires. This feature allows wireless network deploy easily where traditional or wired network become ineffective. The electromagnetic waves are used in wireless network for communication. Two approaches are used to enable wireless communication between two nodes. In the first approach the existing cellular network is allowed to carry the data as well as voice. In second approach nodes form temporary network intend to communicate with each other. Mobile Ad Hoc Network is self-organizable, self-configurable dynamic type of wireless network in which each is free to move anywhere within network. Due to movement of nodes topology changes frequently. Each node in MANET acts as a host and router at same time. The transmission range is limited in mobile ad hoc network multiple hops are used for exchange data between nodes. The nodes in mobile ad hoc network nodes exchange data between each other on the basis of mutual trust attacker or intruder take benefit of this characteristic of mobile ad hoc network. One of these types of attack is black hole attack. Black hole is type network security attack in which malicious node pretend itself to be real node and attract all network traffic towards itself it receive data packets from source node and drop all data packets or forward it to unknown address.

The rest of paper is organized as follows Section 2 describes work done previously. Section 3 describes routing protocols. Section 4 describes black hole attack in Manet. Section 5 describes internet protocol version 6 and its features. Section 6 describes simulation tool used for getting and analyzing results. Section 7 describes performance metrics on the basis of behavior of routing protocols is analyzed. Section 8 describes how simulation is formed. Section 9 represents the conclusion.

2. Related Work

Many researchers shown their keen interest in evaluation of mobile ad hoc network routing protocols under black hole attack some of them discuss below:

Vandna Dahiya [2] presented the performance evaluation of two routing protocols namely AODV and OLSR under black hole attack with 21 nodes by calculating different performance metrics like end-to-end delay, network load and throughput. Network Simulator 2.35 is used as simulation tool. This evaluation illustrated that OLSR performs better under black hole attack as compared to AODV.

Harjeet Kaur et al [5] evaluated the performance of AODV, OLSR and ZRP under black hole attack with 50 nodes and varying number of source nodes on the basis of different performance metrics like packet delivery ratio, average jitter, throughput and end-to-end delay.CBR traffic and Qualnet 5.1 is used for collecting and analyzing results. The findings of study shows that AODV has less vulnerable under black hole attack as compared to rest of two routing protocols.

Amin Mohebi et al [6] studied the performance of AODV and DSR under black hole attack with 8,16,32,64 nodes in terms of end-to-end delay, network load, and throughput by using OPNET Modeler 14.5 .The results showed that DSR is not suited for large networks performance of this routing protocol is varied in large network, AODV performs better under black hole attack.

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Amritbir Singh [8] provided introduction about internet protocol and its versions. This paper also presents performance evaluation of three routing protocols namely DSR, GRP and TORA under IPv6 environment with 10, 20, 30 nodes. The performance differential were analyzed by using end-to-end delay, network load, throughput and OPNET Modeler 14.5.The evaluation exhibited that GRP performs better as compared to rest two routing protocols.

Najiya Sultana et al [9] compared the performance two routing protocols namely AODV and OLSR under black hole attack with 16 and 30 nodes in terms of end-to-end delay, network load and throughput by using OPNET Modeler 14.5.The comparison showed that AODV is impacted more under black hole attack as compared to OLSR.

Irshad Ullah et al [11] analyzed the behavior of AODV and OLSR under black hole attack with 16 and 30 nodes by using quantitative performance metrics like end-to-end delay, network load, and throughput. The evaluation performed upon OPNET Modeler 14.5.Both routing protocols compared under normal working and black hole attack. The simulation results indicated that OLSR is less vulnerable as compared to AODV.

3. Routing Protocols

Routing protocols in mobile ad hoc network mainly categorized as follows:

A. Proactive Routing Protocols: Routing protocols in which each node has their own set of routing tables and it has stored information about other nodes on network in its routing tables are known as proactive routing protocols. The main advantage of these type of routing protocols are nodes can get route information immediately for establish a link.

B. Reactive Routing Protocols: Routing protocols in which route can establish when it needed by source node for forwarding data packets to destination node are known as reactive routing protocols. The reactive routing protocols use flooding technique for discovery of routes. Once route will discover it stored and maintained in route cache. The main advantage of this type of routing protocols is it save the precious bandwidth of ad hoc network.

C. Hybrid Routing Protocols: Routing protocol which acquire the features of both Reactive and Proactive routing protocols are known as hybrid routing protocols. In hybrid routing protocols whole network divided into different zones and Zone ID assigned to each zone. This Zone ID helps to easily recognize the physical location of node on network. The main advantage of hybrid routing protocols are it cause minimum routing overhead in forwarding data packets from source node to destination node. The different routing protocols in MANET are depicted in Figure 1

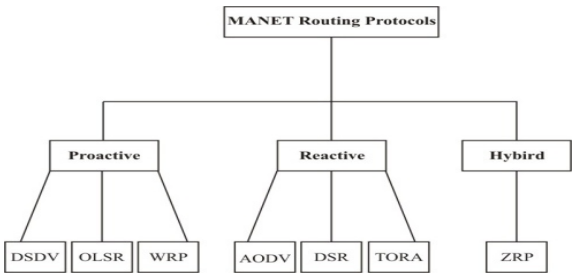


Figure 1: Diagrammatic Representation of Routing Protocols

3.1 Adhoc On Demand Vector (AODV)

Adhoc On Demand Vector is on demand routing protocol in which route will create when it needed. The information about next hop to destination and sequence number which gets from destination stored in routing tables. Due to this problem of loop of messages avoided and retain freshness in information received. Four types of control messages are used. The RREQ (Route Request) message is used when source node wants to establish a link with destination node. When destination node receive RREQ (Route Request) message from source node it transmits RREP (Route Reply) message towards source node. It means destination node is alive and link is fresh. When link between source and destination node is failed RRER (Route Error) message transmit by destination node to inform source node that link not longer valid. The RREP-ACK (Route Acknowledgement) message sent by destination node towards source node when acknowledgement option is selected [7].

3.2 *Dynamic Source Routing* (DSR)

Dynamic Source Routing Protocol is on demand routing protocol which used source routing approach for forwarding data packets from source to destination. Source routing is an approach in which data packet header contains complete list of nodes from which data have to pass.DSR performs two types of functions: Route Discovery and Route Maintainence.When source node wants to establish a connection it transmits RREQ (Route Request) message to each intermediate node when each intermediate node received this message it retransmit it, until it either reach to the destination node or intermediate node has information about route to destination node in its route cache. Once destination node received RREQ message it transmits RREP (Route Reply) message towards source node and stored information about route in its route cache for future use. If the link fails the destination node transmits RERR (Error) message to source node. The RERR message is generated by destination node to inform source node that link is failed and no longer valid. If links failed the source node removed its information from it route cache. If information about new route to destination is available in route cache it is replaced with previous one. If no such link will available in route cache route discovery is reinitiated [4].

3.3 Geographical Routing Protocol (GRP)

Geographical Routing Protocol is a position based routing protocol. Geographical Routing Protocol assumes two assumptions that nodes are aware about their own and their

immediate neighbor's geographical positions. The routing table is not used geographical routing protocol for routing of data to destination it depends upon the information available with each node about its immediate neighbors. Two types of routing algorithm are used in geographical routing protocols: Greedy Routing and Face Routing Algorithm. In greedy routing algorithm data packets brought closer to destination node in each step by selecting suitable neighbor. In face routing algorithm in which considered that each regions is separated by edges of planner graph. The routing algorithm takes way around the face it begins from the point closest to the destination and explores next face closest to destination. Greedy routing is failed if there is no next hop closest to destination find among neighbor nodes. Then greedy routing switches over to perimeter mode forwarding and then it continues to explore next closest point to destination [10].

3.4 Optimized Link State Routing (OLSR)

Optimized Link State Routing is table-driven link state routing protocol based upon the concept of multi-point relay(MPR).It helps to reduce control traffic overhead. In OLSR all nodes elect MPR among themselves. This MPR transmit control messages on behalf of other nodes in the network. Each node has own set of MPR.OLSR most suitable for large and dense network. It provides shortest path to destination node. Different types of control messages are used in OLSR.Hello messages are used for find link state information for host neighbors. Topology Control (TC) messages are used for broadcasting information about own advertised neighbors which includes at least MPR selector list. Multiple Interface Declaration(MID) messages are used for inform other nodes within network that announcing node used multiple interfaces of OLSR.Host and Network Association(HNA) messages are used for providing external routing information and giving possibility for routing to external addresses[1].

4. Black Hole Attack in MANET

Black Hole is type of attack in which malicious node uses its routing protocol falsely claims it have a shortest path towards destination node and advertises its availability of fresh route towards destination node without checking its routing tables. Therefore malicious node is always present for reply route request of source node. The flooding technique is used by malicious node for transmit route reply message in response of source node route request message before actual node respond. Thus forged route is created, now it is up to the node whether it drops the data packets or forwarding it on unknown address. Black Hole Attack explained in Figure 2 in which node "A" wants to send data packets towards node "D" and initiate route discovery process but node "C" is malicious node it falsely claims itself active route towards destination when it received route request message from node "A" it send route reply message to node "A" in response its route request message before other nodes respond. The node "A" received the route reply message from node "C" and thought it active and fresh route towards the destination and route discovery is complete Node "A" starts sending data packets towards node "C" and ignore other nodes requests. Thus data packets consumed or lost. Due to this network overhead increased and precious bandwidth of network is wasted.

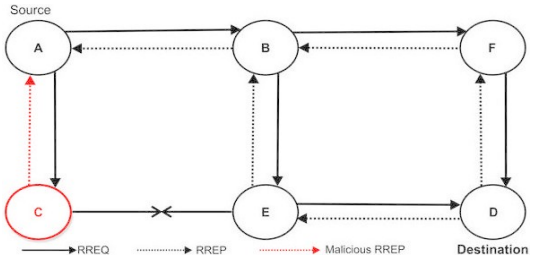


Figure 2: Black Hole Problem

5. Internet Protocol Version 6

The depletion of address in IPv4 (Internet Protocol Version 4) mobile nodes not allow to obtain IP address from regional address registries to access internet. To overcome this problem IETF(Internet Engineering Task Force) deployed IPv6(Internet Protocol Version 6) in year 1999.It is also known as IPng(Internet Protocol for Next Generation).With deployment of IPv6 put internet technology on next level.IPv6 has certain features which make it more efficient as compared to IPv4 which discuss as follows:

5.1 Larger Address Space

As compared to internet protocol version 4(IPv4) internet protocol version 6(IPv6) has more address space which helps to solve the address exhaustion problem of internet protocol version 4(IPv4).Internet protocol version 6(IPv6) has provide 128 bits address space which equals to approximately 3.4×10^{38} addresses[3].

5.2 Simplified Header

The IPv6 header is less complex and easier to process as compared to IPv4 header. In IPv6 header fragmentation fields and other optional fields placed under extension header. This allows processing IPv6 headers efficiently at intermediate routers without having parsed to network headers or recompute network-layer checksums. Due to these processing router overhead decreases, making network hard fewer complexes and allow packets to process much faster. IHL (Internet Header Length), identification, flags fields are not present in IPv6 header. Time-To-Live (TTL) field of IPv4 header which is used to preventing routing loops has changed name to Hop Limit [3].

5.3 End-To-End Connectivity

The peer-to-peer applications such as multiplayer online games, video-conferencing, file sharing and VoIP need unique IP address for communication. Due to shortage of addresses IPv4 unable to fulfill their demand. To overcome it Network Address Translation (NAT) is used NAT translate one unique global address to multiple private addresses. In absence of unique IP address it is difficult for NAT to provide end-to-end

services.IPv6 has larger address space compared to IPv4 thus IPv6 is able to provide end-to-end services efficiently and NAT is no longer requires [3].

5.4 Auto-Configuration

The plug and play option of IPv6 allows network devices to configure themselves independently. It is more fruitful for mobile devices when mobile devices in their home network it connects through its home link if it away from their home network then home network acts as a router for it and establish mobile device link with other devices on network. Two types of Auto configuration schemes offered by IPv6 first one is Sateful Auto-Configuration in it Dynamic Host Configuration Protocol for IPv6(DHCPv6) is used for installation and administration of nodes on over network.DHCPv6 server maintains list of node and information about their state to know availability of IP address from range specified by network administrator. The second scheme is Stateless Auto-Configuration it allows each hosts to determine its address form content of advertisement received from each user [3].

5.5 Built-in Security

IPSec (Internet Protocol for Security) is mandatory for IPv6 thus IPv6 is more secure as compared to IPv4.IPSec is contains set of cryptographic protocols which ensure secure communication. Authenticate Header of IPSec enables authentication and maintain integrity of data. Encapsulating Security Payload provides authentication, integrity and privacy of data. Internet Key Exchange set up security parameters between two end points and keeps track this information for secure delivery of data till end [3].

5.6 Quality of Service Support

QoS is a important feature of IPv6. IPv6 header contains new field named Flow Label it defines how particular packets are identified and handled by routers. In other words packets start from particular host to particular destination identified and handled by routers efficiently and quickly. The Flow Label field ensures efficient delivery of information from one end to another end without any alteration by intermediate nodes [3].

5.7 Better Mobility Support

MIPv6 (Mobile IPv6) is mandatory for IPv6.MIPv6 allows mobility between various technologies such as from cellular network to wireless network. There is no ingress-filtering in MIPv6 because correspondent node cares the address of source node. Ingress-filtering is technique which ensures that incoming packets actually came from the network from where it's claim to originate.MIPv6 use extension header and provides route optimization between two mobile nodes when roaming between different 3G networks. The mobile devices demands voice, video and data which fulfilled by the standard known as IMS (IP Multimedia Subsystem).IMS requires each node has unique IP address to provide bi-directional services. The large address space of IPv6 ensures that each node has own unique IP address [3].

5.8 Any Cast and Multicast

Multicast is a technique in which data packets not send from source node to destination node in it data packets travels from one stage down to another stage in hierarchical tree manner.IPv6 extends capabilities of IPv4 it provides large multicast address range. It improves the network efficiency.IPv6 also improves the any cast services which are very minimal in IPv4.In any cast services packets not sent to all nodes in network but to nearest node. The any cast services use tremendously in discovery of DNS server from the group of servers [3].

5.9 Easy Administration

When existing network expands or two networks merge network renumbering is needed and new address assign to it. In IPv6 network renumbering not done manually it done automatically. Thus there is no need for manually reconfigure each host and router.IPv6 supports multihoming.Multihoming is a technique which connection establish with two ISPS (Internet Service Providers) at same. If connection from one ISP is lost there has another backup connection to internet. This ensures reliability in services there are more than one from source to destination [3].

6. Simulation Tool

This research is performed on OPNET Modeler 14.5. OPNET(Optimized Networking Engineering Tool) which is originally developed for military needs it has certain features on the basis it become widely used commercial network simulator.OPNET has huge library of networkmodelsand protocols which helps in designing and modeling of communication networks efficiently.OPNET allows researchers to modify these network models and develop their own network models.OPNET adopt hierarchical structure for modeling at each level of hierarchy describes different aspects of network model. OPNET used object oriented modeling approach nodes and protocols are modeled as classes with inheritance. OPNET provides functionality in the fields of design and assessment of MANET routing protocols, analysis of optical networks and enhancements in the core network technologies such as IPv6.Due to usage of graphical user interface it easy to simulate network in it as compared to other network simulators.

7. Performance Metrics

1. End-To-End Delay: End-To-End Delay represents average time that taken by a data packet to reach its destination. This metric is calculated by subtracting time taken by first data packet to traverse the network from time at which first data packet arrived to destination.

2. Network Load: Load submitted to wireless LAN layers by all higher layers in WLAN nodes network represents in bit/sec. When more traffic is coming on the network it is difficult for network to cope up with this heavy load of traffic it is called

network load. Heavy load on network may affect the performance of network. The performance of network is decreases. In heavy load data packets may collide this may cause congestion on the network and makes the routing process slow.

3. Throughput: It is ratio of total amount of data transfer from sender to receiver and time taken by receiver to receive last packet of data from sender. In other words we can say that it calculates how constantly data is provided by network to receiver. Throughput is the number of data packets arriving at receiver per milliseconds.

8. Simulation and Performance Analysis

Simulation process is divided into different scenarios. All nodes are randomly deployed under static linear fashion in campus network environment of 4000X4000 square meters.FTP with high load traffic is used as traffic pattern. The file size is 50,000 bytes .Every node moves with constant speed of 10 m/s with 80 seconds pause time. All nodes are defined as manet stations with one WLAN server. WLAN connection speed is 11 Mbps.The simulation time is 10 minutes. The parameters used in this study are summarized below in Table 2:

Table 2: Parameters of Simulation

Parameters	Value
Simulator	OPNET 14.5
Number of Nodes	10,20 and 30
Maximum Speed	10 m/s
Simulation Time	10 minutes
Pause Time	60 sec
Environment Size	4000X4000
Packet Inter Arrival Time	exponential(1)
Packet Size	exponential(1024)
Traffic Type	FTP
Mobility Model	Random Waypoint
Data Rate	11 Mbps
Addressing Mode	IPv6

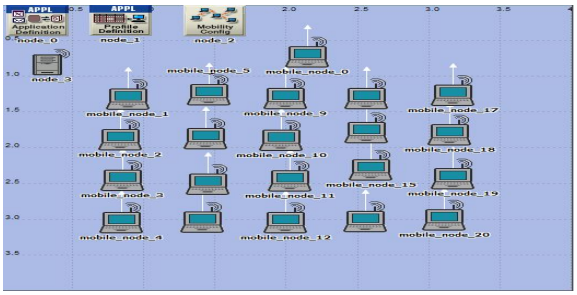


Figure 3: Perposed Experimental Setup

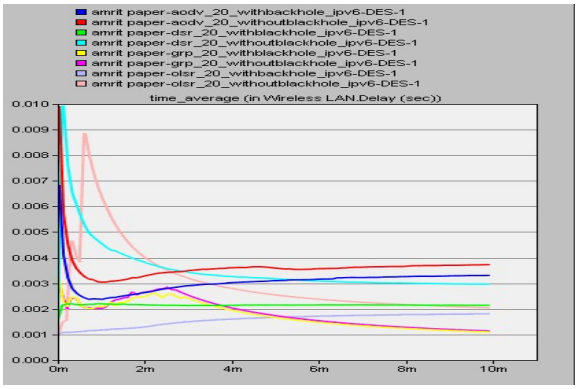


Figure 4: End-To-End Delay for 20 Nodes

The figure 4 presents evaluation of four routing protocols namely AODV,DSR,GRP,OLSR in terms of end-to-end delay for 20 nodes.The behaviour of attack is depends upon protocol type,routing procedure and number of nodes.All routing protocols evaluated under normal working and black hole attack.The results of normal working compared with black hole attack for analyze the overall effect of black hole attack on whole network.It is evident from the graph that end-to-end delay is higher in normal working of routing protocols as compared to under black hole attack because there is no need of route request and route reply message malicious node send route reply message to source node prior to destination node it exhibits less end-to-end delay under black hole attack.Due to its reactive nature end-to-end delay is higher in AODV under black hole attack.GRP performs better in terms of end-to-end delay under black hole attack.

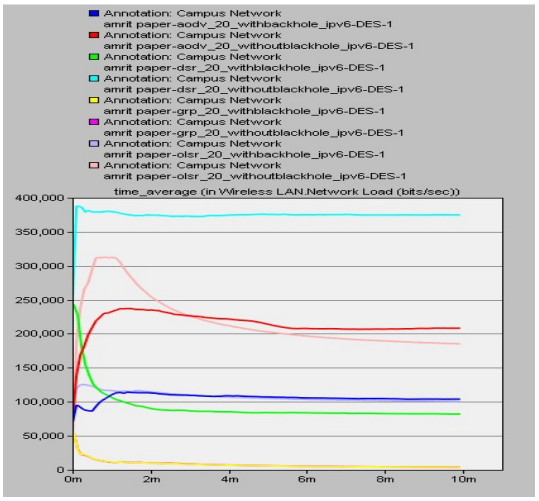


Figure 5: Network Load for 20 Nodes

The figure 5 presents the evaluation of four routing protocols namely AODV,DSR, GRP and OLSR in terms of network load for 10 nodes under normal working and black

hole attack.It is depicted from graph that network load in routing protocols under normal working is higher as compared to network load under black hole attack because malicious node discards data packets instead of forwarding it to destination node thus reduction in network load.When comparison drawn between routing protocols it found that network load is higher in DSR under black hole attack as compared to other routing protocols.GRP performs better under black hole in terms of network load.

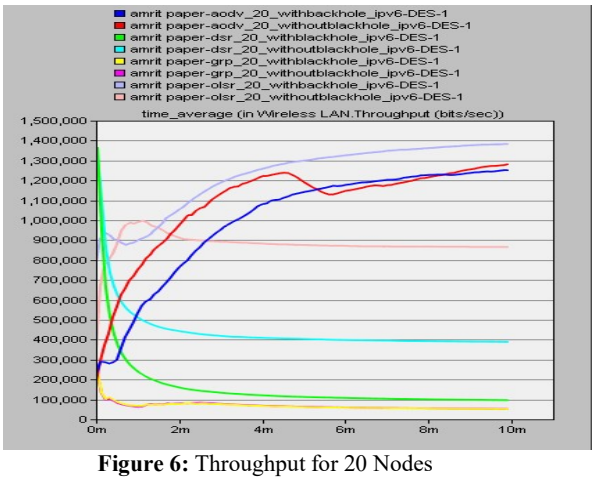
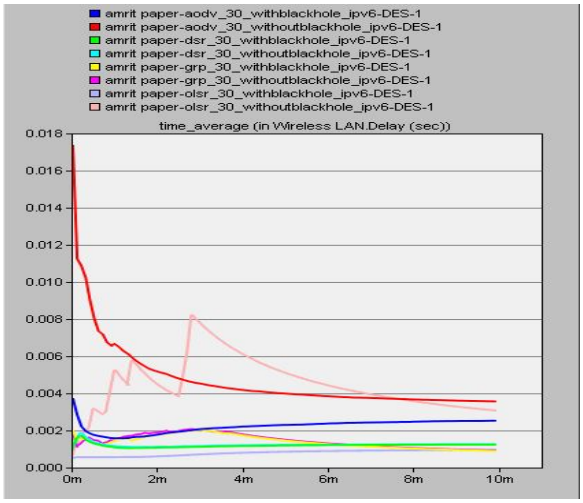


Figure 6: Throughput for 20 Nodes

The figure 6 presents evaluation of four routing protocols namely AODV,DSR,GRP and OLSR in the terms of throughput for 20 nodes under normal working and black hole attack.Due to discarding of data pactkets by malicious node instead of forwarding it to destination node thus throughput is effected. It is also evident from graph that throughput under normal working is higher as compared to under black hole attack.Throughput in OLSR is higher under under black hole attack as compared to other routing protocols.



. **Figure 7:** End-To-End Delay for 30 Nodes

The percentage of end-to-end delay slightly increases in figure 7 due to increase in number of nodes.Figure 7 shows evaluation of four routing protocols namely AODV,DSR , GRP and OLSR in terms of end-to-end delay for 30 nodes under normal operation and black hole attack is presented.It is evident from graph that end-to-end delay is higher under normal operation compared to under black hole attack.The end-to-end delay is higher in AODV uner black hole attack as compared to other routing protocols.DSR performs better under black hole attack as compared to other routing protocols in terms of end-to-end delay.

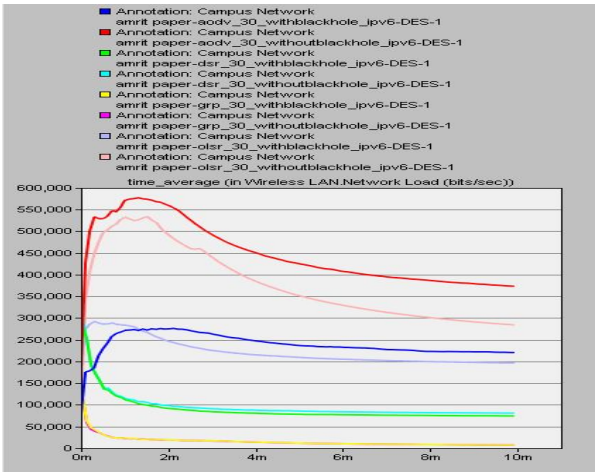


Figure 8: Network Load for 30 Nodes

In figure 8 evaluation of four routing protocols namely AODV,DSR,GRP and OLSR in terms of network load for 30 nodes under normal operation and under black hole attack is presented.It is evident from graph that network load is higher under normal operation as compared to under black hole attack.This is due to data packets discarded by malicious node instead of forwarding it to destination node.The network load in AODV under black hole attack is higher as compared to other routing protocols.GRP performs better in terms of network load under black hole attack.

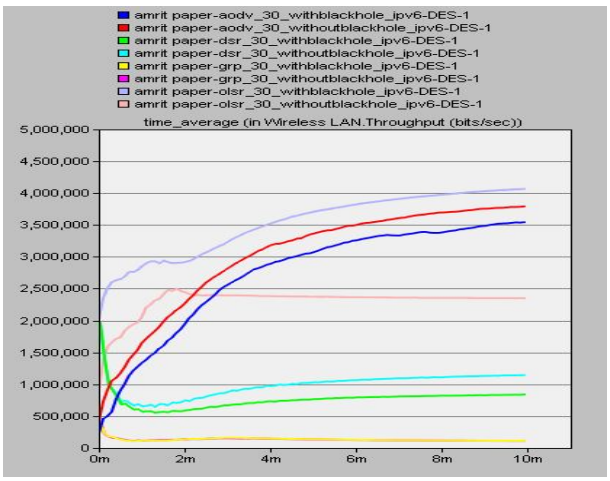


Figure 9 : Throughput for 30 Nodes

In figure 9 evaluation of four routing protocols namely AODV,DSR,GRP and OLSR in terms of throughput for 30 nodes under normal operation and black hole attack is presented.The data packets discarded by malicious node instead of forwarding it to destination node it effects the throughput.It is also evident from graph that throughput is higher under nornal operation as compared under black hole attack.The throghput in OLSR under black hole attack is higher as compared to other routing protocols.The resulant values depicted in Table 3

Table 3: Resultant Values

Protocols	Number of Nodes	End-To-End Delay(Sec) Without Attack	End-To-End Delay(Sec) With Attack	Network Load (Bit/Sec) Without Attack	Network Load (Bit/Sec) With Attack	Throughput (Bit/Sec) Without Attack	Throughput (Bit/Sec) With Attack
AODV	20	0.00489	0.005857	279401	145870	1777464	1757224
DSR	20	0.01836	0.002745	532149	97225	399840	97225
GRP	20	0.006340	0.005642	22740	20369	179487	159063
OLSR	20	0.03911	0.002020	412772	157337	1335072	1158133
AODV	30	0.01008	0.003323	735617	364475	4877007	4851844
DSR	30	0.002205	0.002947	148012	118008	1894323	1307892
GRP	30	0.003282	0.003371	25479	25160	334248	253260
OLSR	30	0.02880	0.001116	716876	330899	5023577	2745627

9. Conclusion

All routing protocols have different architecture due it behaves differently under different conditions.It is must to check performance of routing protocols under different environments This resarch investigates the impact of black hole attack on four routing protcols namely AODV,DSR,GRP and OLSR under IPv6.On basis of observations it found that OLSR performs better in terms of end-to-end delay and throughput under black hole attack .GRP less effected in terms of network load under black hole attack.At the end it concluded that OLSR perfoms better under black hole attack as compared to other routing protocols.The performance of all routing protocols under black hole attack are summarized in Table 4 A denotes for best performance and D denotes for worst performance.

Table 4: Resultant Values

Protocols	End-To-End Delay	Network Load	Throughput
AODV	D	D	B
DSR	C	B	C
GRP	B	A	D
OLSR	A	C	A

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