Enhanced Performance and Security for Manet's Against Blackhole Attack Blackhole Attacks

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DOI: https://doi.org/10.21467/proceedings.1.14

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Abstract

Manet is a decentralized infrastructureless network in which user can communicate with each and every node within it's radio range. Each node in MANET acts as router as well as host. There have been many routing protocols proposed but the major drawback of these protocols is node mobility, time consumption, resource consumption and high bandwidth constraint. This paper introduces enhanced BRM [blackhole resisting mechanism] concept in which each node is responsible for monitoring the behaviour of its neighbour nodes to detect malicious node and to exclude them. And also introduces a concept of modified Self Protocol Trustiness[SPT], in which it will send a fake RREQ at random interval of time to detect if any misbehave. With the help of Dynamic Source Routing[DSR]protocol the optimal path will be identified between any original source and destination which is free from identified malicious nodes. In the existing BRM, the packets are flooded throughout the network inorder to identify the neighbour nodes this results in traffic congestion. The proposed enhanced BRM overcomes the drawback of the existing BRM by introducing node classification mechanism.

Index terms---MANET, Routing, Black-hole, Self-Protocol Trustiness

1 INTRODUCTION

Manet is a decentralized infrastructureless network in which user can communicate with each and every node within it's radio range. Each node in MANET acts as router as well as host. There have been many protocols proposed but the major drawback of these protocols is node mobility, time consumption, resource consumption and high bandwidth constraint.

Proactive or Reactive are the two-main classification of MANET routing protocols. The proactive routing protocol is also called as table driven routing protocol, in which each node will be having one or more tables containing routing information to every other node in the network. Whereas in reactive(on-demand) routing protocols, when a source requires to send a data to a destination node a route will be created, this also means that these protocols are initiated by source on-demand. This paper focuses on the AODV protocol which is one of the widely studied reactive protocols, considered by the IETF for standardization.

Existing MANET routing protocols assume that all nodes cooperate without maliciously interrupting the operation of the protocol and do not provide security against malicious attackers. Because of wireless nature of network, the presence of malicious node cannot be ignored in computer network especially in MANET. It inherits security threats that are faced in wired as well as in wireless networks and also introduces security attacks which are unique to itself due to its characteristics. In MANET, nodes have limited computations and power capabilities that make the network more unprotected to denial of service attacks(DoS).

As cryptography and key management algorithms require significant computations it is hard to implement them. It is difficult to distinguish between unoriginal (stale) route and fake route due to node mobility. A malicious node can attack network layer in MANET either by not forwarding packset or by changing the parameters of routing messages such as sequence number and IP address, sending fake message several times and sending fake routing information to disrupt routing operation.

There are many solutions proposed to resist large number of attacks on MANET.There are security mechanism that can be added to existing routing protocols to resist attacks. To ensure the authenticity and integrity of routing messages cryptography techniques are used. A major concern is to have both performance and security or any one with the limited resources available at many MANET nodes. Example of these security enhanced protocols are Authenticated Routing for Ad-hoc Networks(ARAN), Secure Link State Routing Protocol(SLSP), and Secure Ad-hoc On-demand Distance Vector routing(SAODV).The performance of secured mechanism using cryptographic technique will be worse than the non-secured mechanism in presence of some attacks. The detection of malicious node is not guaranteed by securing the routing message.

This paper introduces enhanced BRM [blackhole resisting mechanism] concept in which each node is responsible for monitoring the behaviour of its neighbour nodes to detect malicious node and to exclude them. We assimilate our proposed mechanism into AODV as an example of its use with on-demand routing protocols. In this paper, we observe significant improvement in performance when using our mechanism.

2 AODV UNDER BLACKHOLE ATTACK

The one among the reactive routing protocols is AODV. To ensure the freshness of routes and guarantee loop freedom it uses destination sequence numbers. A node broadcasts a route request (RREQ) packet to its neighbours using a new sequence number to find a path to a destination. As soon as each node receives the broadcast, it sets up a reverse route towards the originator of the RREQ unless it has a fresher one. Intermediate node or destination node unicasts a reply by sending a route reply (RREP) packet along the reverse path when the intended destination or an intermediate node that has a fresh route to the destination receives the RREQ during the route discovery process. For the node which responds first with an

RREP, then the source node starts sending data packets to the destination node through the neighbouring node.

The active route which deal with data transmission, the source node, the destination node and the intermediate nodes contains the routing information. This scenario minimizes the use of network resources, decreases the memory overhead and runs well in high mobility situations.

A malicious node absorbs the network traffic and drops all packets in blackhole attack. A malicious node immediately sends a false RREP, once it receives a RREQ packet from any other node; with a high sequence number and hop count equals 2 (i.e. one-hop from the source and the destination); without checking its routing table. The source node receives the first reply from the malicious node. The route including the malicious node is selected which has high sequence number. The data packets are droped rather than forwarding them to the destination node, when the data packets routed by the source node reach the blackhole node.

A fake RREP generated by a malicious node initiating a blackhole attack for each RREQ it receives to incorporate itself in a route, therefore all packets are sent to a point where they are not forwarded anywhere which is a form of a denial of service (DoS) attack. A node cannot detect whether the neighbor that sent the RREP is malicious or not. The network performance is highly affected by blackhole attack.

3 RELATED WORK

Since the on-demand routing protocols have been in- traduced, there are many algorithms that have been proposed to secure MANET against blackhole attack. Many algorithms use cryptographic technique to secure routing packets. Although cryptographic techniques are efficient to provide security for routing packets, but it fails to suit MANET characteristics by using more computations and more resources at network nodes. There are many solutions that suggest modifications to routing protocol by adding some packets, modifying the existing packet or changimg the procedure of these protocols.

These solutions focus mainly on two characteristics of the RREP received from a blackhole node; the first is that the balckhole node will send the RREP packet before any other node sends as a result there is no need to check the route table. The second is that the fake RREP packet sent by blackhole node tries to convince the original node that it has fresh path to destination node. But these solutions do not guarantee that the excluded nodes will be the original blackhole nodes. In this section we introduce some of the existing algorithms used to avoid the blackhole attack.

S. Lee [7] introduced two new packets; the route confirmation request (CREQ) and route confirmation reply (CREP) that was a proposed solution that modified the AODV routing protocol. An intermediate node has to send CREQ to its next- hop node toward the destination node in addition to RREP to the source node. When the next-hop node receives CREQ, it looks up its cache for a route to the destination. If there is a route to destination, it sends the CREP to the source. The source node will confirm the validity of the path only after receiving the CREP, by comparing the path in RREP and the one in CREP. If both are coordinated, the source node judges the appropriate route. If two consecutive nodes work together as the first node asked its next hop node to send CREP to the source, then there will be a drawback which cannot avoid the cooperative blackhole attack. In our proposed mechanism we can overcome this drawback with one-hop neighbour identification technique.

L. Tamilselvan [16] proposed a solution that designed upon a Fidelity Table in which each participating node is assigned with a fidelity level that determines the node reliability and the fidelity level is updated based on the behavior of the node when a default fidelity level is assigned to each node. The source node selects a neighbor node with a highest fidelity level to forward data to the destination node only when it receives RREP, and also it waits to receive further route replies from its neighboring nodes. A destination node acknowledges by sending ACK after receiving the data. The Updation fidelity level of node depends on trusted participation of the node in the network. The fidelity level of the forwarding node is incremented or decremented by source node upon receiving or missing the ACK respectively. If the fidelity level of node reaches zero, then it is eliminated from network and marked as a malicious node. The main drawback of this solution is, the fidelity level of authorized node is decreased when the malicious node is present as a neighbor node. In our proposed system, we can overcome the above drawback by using one-hop neighbor identification where each hop monitors it's neighbor.

N. Mistry [8] proposed a solution that depends on analysing all received RREP. The source node maintains a table in which it stores all the received RREPs. Then it makes an analysis of all stored RREPs from the table and rejects any having very high destination sequence number and considering its sender as malicious. The remaining entries in the table are arranged according to their destination sequence number and the node with the highest number is selected. This technique also records the identity of suspected malicious nodes to discard any upcoming control packets received and/or forwarded from/to that node and a routing entry for that node will not be maintained. The algorithm introduces high end-to- end delay as nodes have to wait for multiple RREPs. In our proposed system we use DSR (Dynamic Source Routing) protocol to overcome the delay by finding the optimal path from original source to destination node excluding the malicious node.

N. Choudhary [4] introduced a solution that based on sensing the wireless channel. This approach assigns a max trust value and min trust value to all its neighboring nodes. A node will not do any further communication with a neighbor whose trust value is less than min trust value. The routing table will be updated when a source node receives a RREP message, it starts transmitting the data packets and inserts a unique sequence number with each transmitted data packet. When a node forwards a data packet, it sets a timer and listens to the wireless channel in promiscuous mode to ensure that this packet is forwarded by a next hop neighbor. When the timer expires without hearing the retransmission of this packet, the node reduces the trust value for its next hop node. Trust value information is updated and disseminated to other neighboring nodes. If the trust value of a node decreases below min trust value, it will be isolated by all the nodes in the network.

In our proposed system, the efficiency and performance are improved.

Mohamed A. Abdelshafy and Peter J. B. King [19] proposed a mechanism that introduces a new concept of Self-Protocol Trustiness (SPT) which clarifies that the detection of a malicious node is accomplished by complying with the normal protocol behavior and attracts the malicious node to give an implicit architecture of its malicious behaviour. The mechanism does not use cryptographic techniques which conserves the power and computation resources. In this mechanism the nodes that are in threat state can be sent back to the normal state, but in our proposed system once the node is blacklisted it can never be sent back to normal state. In the existing BRM, the packets are flooded throughout the network inorder to identify the neighbor nodes this results in traffic congestion.

The proposed enhanced BRM overcomes the drawback of the existing BRM by introducing node classification mechanism.

4 BRM-AODV PROTOCOL

For the fast detection of blackhole neighbors, BRM-AODV is designed to mitigate the effect of the blackhole attack on the performance of AODV protocol. Self-Protocol Trustiness (SPT) is the new concept used in this mechanism, which clarifies that the detection of a malicious intruder is accomplished by complying with the normal protocol behavior and lures the malicious node to give an implicit avowal of its malicious behavior. Cryptographic techniques conserve more computation resources and

Power, hence this is mechanism is not used in BRM-AODV protocol. Furthermore, the mechanism neither modifies the existing ones nor adds new routing packets. By storing the last three per hop times for a RREP received for a destination, a small modification to the original AODV is introduced.

By considering the latency between sending a RREQ and receiving its corresponding RREP divided by the hop count value included in the RREP, per hop time is calculated. To detect any misbehave in blackhole, each node in the network has to monitor the performance of its neighbors. A fake RREQ from a non- existant source node to a non-existant destination node is sent periodically by a node. A node which is malicious will only respond to this fake RREQ. If a node receives a RREP from any one of its neighbors to its fake RREQ, the node becomes sure that this neighbor is a blackhole node.

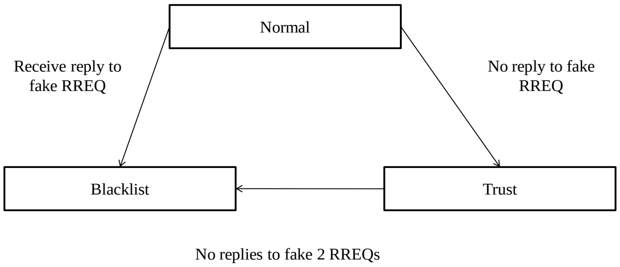


Fig. 4.1. FSM of Node Trust Level

Normal level and Trust level are the two different variables introduced in this algorithm as shown in fig 4.1 . When a node joins a network, it sets its trust level to normal and updates to either trust or blacklist upon reception of replies to its fake RREQs. Fig 1 shows the operation of trust levels as a finite state machine. . A node implementing the Blackhole Resisting Mechanism behaves as follows:

1. From a random non-existing source node to a random non-existing destination node, a node periodically sends a fake RREQ. These fake source and destination addresses are stored in the trustiness table for later examination by the node . To avoid the table inflation.,the node also sets an expiry time for each of its entry.
2. A node sends fake RREQs at random time intervals between MIN NORMAL and MAX NORMAL by initialising its trust level to normal. It changes its trust level to Blacklist, if a node receives a reply to one of its fake RREQs.

   Node upgrades it trust level from normal to trust without receiving a reply during RREP VALIDATE period for two successive fake RREQs. A node set its trust level to trust and sends fake RREQs at random time interval between the MIN NORMAL and MAX NORMAL interval, MIN TRUST and MAX TRUST,these intervals introduce more difficulty for a malicious node.
3. It is suggested that the TTL value of this fake RREQ is set to a random number between TTL__MIN(1) and TTL_MAX(4) to solve the problem of flooding the network with fake RREQs which increases the routing over-head and detection of validity of the RREQ by a malicious node.
4. If both fake source and destination addresses are found in the trustiness table and if a RREP is received from a neighbor for this fake RREQ, and the source address of this reply is identical to the forwardingneighbor, the node identifies the originator as

a blackhole node by setting it to blacklist and drops any upcoming RREPs received from this neighbor without processing.

5. If source address of this reply is not identical to the forwarding neighbor and if both addresses of fake source and destination are found in the trustiness table, and if a RREP is received from a neighbor for this fake RREQ, node identifies that this neighbor may be a victim used to forward this RREP or a malicious node that tries to ruin our algorithm.

V RESULTS

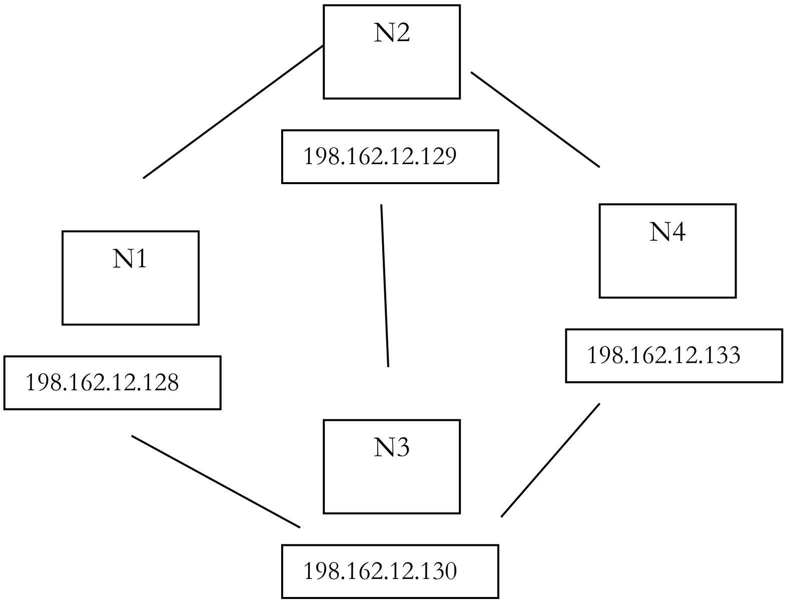
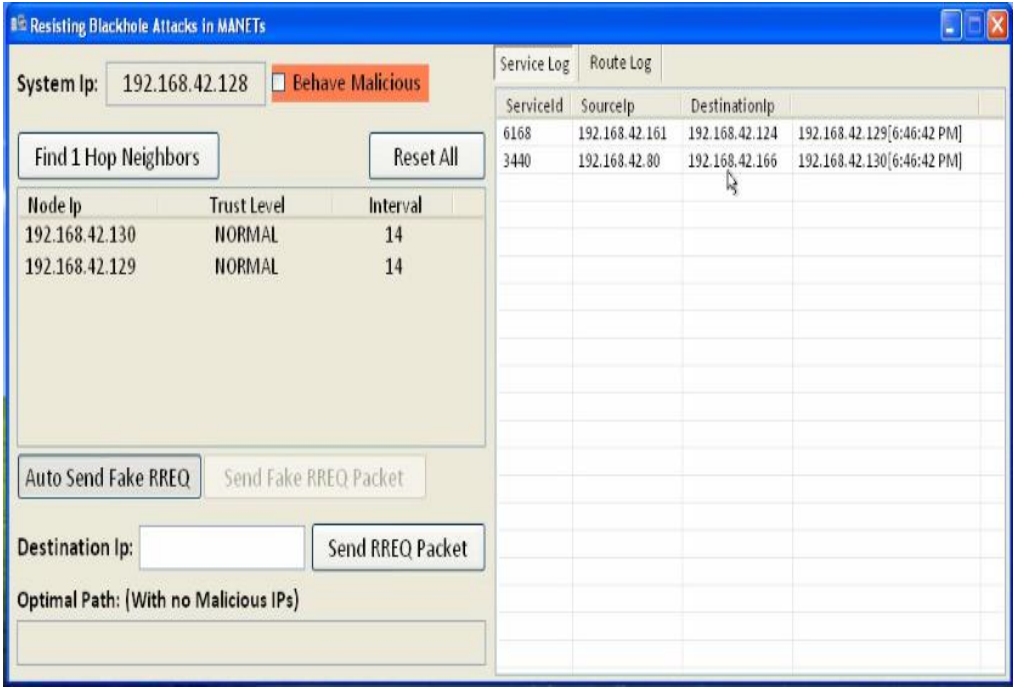


Fig 5.1: Network topology for case 1.

- In figure 5.1, we consider 4 devices namely node 1, node 2, node 3 and node 4 in case 1.
- Nodes have following IP addresses: 192.168.12.128, 192.168.12.129, 192.168.12.130, 192.168.12.133.
- Node 1 is considered as source node, node 4 is considered as destination node , node 2 and node 3 are considered as neighbour nodes.
- All nodes can communicate with each other directly except node 1 and node 4.



System Ip: 192.168.42.128 ☐ Behave Malicious

Node Ip	Trust Level	Interval
192.168.42.130	NORMAL	14
192.168.42.129	NORMAL	14

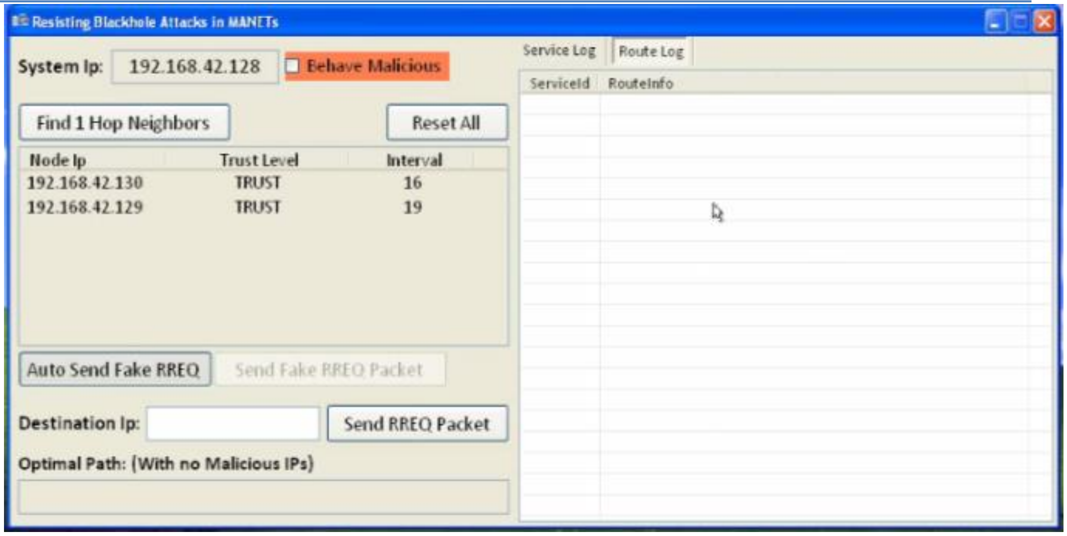
Destination Ip:

Optimal Path: (With no Malicious IPs)

ServiceId	SourceIp	DestinationIp	
6168	192.168.42.161	192.168.42.124	192.168.42.129[6:46:42 PM]
3440	192.168.42.80	192.168.42.166	192.168.42.130[6:46:42 PM]

Figure 5.2: 1-hop neighbour identification and fake RREQ transmission

- Inorder to identify the neighbour nodes in the network topology, 1-hop neighbour identification using HELLO exchange mechanism is used.
- The source node(N1) identifies its neighbour's as N2 and N3 by clicking on Find on 1 hop neighbour.
- Initially the trust level is set to Normal and Interval is set to 0.
- After identifying neighbours of source node, to send a fake RREQ packets, Auto send fake RREQ is enabled and the interval is changed.
- The fake RREQ packets are sent in the interval between MIN NORMAL 30S and MAX NORMAL 90s.
- In the service log, the fake packet's service id, source IP and destination IP is displayed.



System Ip: 192.168.42.128 □ Behave Malicious

Node Ip	Trust Level	Interval
192.168.42.130	TRUST	16
192.168.42.129	TRUST	19

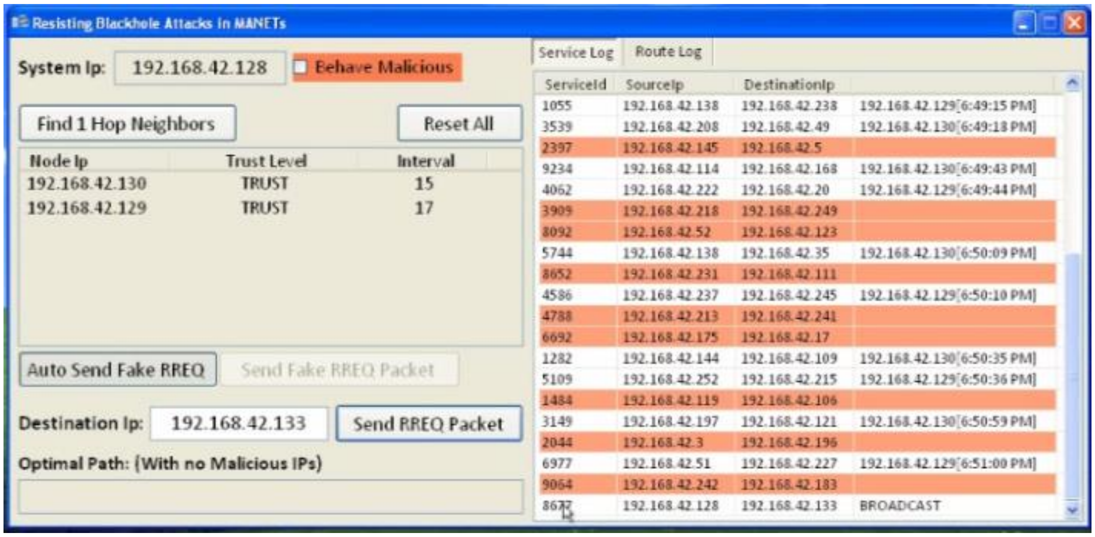
Destination Ip:

Optimal Path: (With no Malicious IPs)

ServiceId	RouteInfo

Figure 5.3: Node classification module

- Since the N2 and N3 does not give RREP to fake RREQ sent by N1, hence N2 and N3 trust level is updated to trust and its interval is changed.
- To identify the trust level, the interval used are between MIN TRUST 90s and MAX TRUST 150s.



System Ip: 192.168.42.128 □ Behave Malicious

Node Ip	Trust Level	Interval
192.168.42.130	TRUST	15
192.168.42.129	TRUST	17

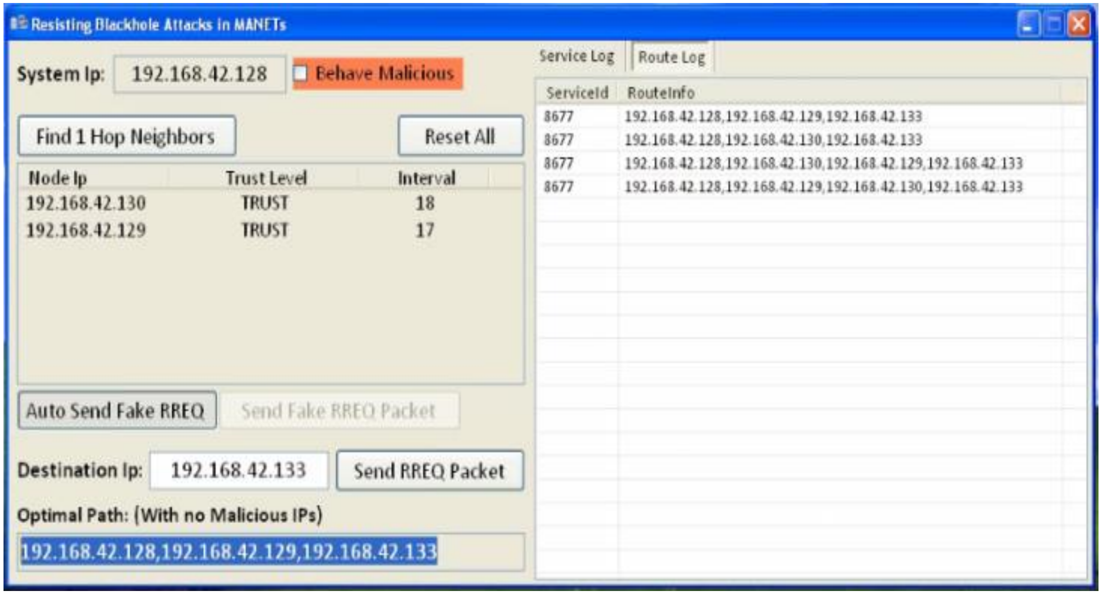
Destination Ip: 192.168.42.133

Optimal Path: (With no Malicious IPs)

ServiceId	SourceIp	DestinationIp	
1055	192.168.42.138	192.168.42.238	192.168.42.129[6:49:15 PM]
3539	192.168.42.208	192.168.42.49	192.168.42.130[6:49:18 PM]
2397	192.168.42.145	192.168.42.5	
9234	192.168.42.114	192.168.42.168	192.168.42.130[6:49:43 PM]
4062	192.168.42.222	192.168.42.20	192.168.42.129[6:49:44 PM]
3909	192.168.42.218	192.168.42.249	
8092	192.168.42.52	192.168.42.123	
5744	192.168.42.138	192.168.42.35	192.168.42.130[6:50:09 PM]
8652	192.168.42.231	192.168.42.111	
4586	192.168.42.237	192.168.42.245	192.168.42.129[6:50:10 PM]
4788	192.168.42.213	192.168.42.241	
6692	192.168.42.175	192.168.42.17	
1282	192.168.42.144	192.168.42.109	192.168.42.130[6:50:35 PM]
5109	192.168.42.252	192.168.42.215	192.168.42.129[6:50:36 PM]
1484	192.168.42.119	192.168.42.106	
3149	192.168.42.197	192.168.42.121	192.168.42.130[6:50:59 PM]
2044	192.168.42.3	192.168.42.196	
6977	192.168.42.51	192.168.42.227	192.168.42.129[6:51:00 PM]
9064	192.168.42.242	192.168.42.183	
8677	192.168.42.128	192.168.42.133	BROADCAST

Figure 5.4: Route discovery packet transmission

- To select the optimal route between original source(N1) and original destination(N4) which is free from identified malicious nodes, DSR (Dynamic Source Routing) protocol is used.
- After entering destination IP address, to broadcast original packet to destination, send RREQ packet checkbox is enabled.



Resisting Blackhole Attacks in MANETs

System Ip: 192.168.42.128 ☐ Behave Malicious

Node Ip	Trust Level	Interval
192.168.42.130	TRUST	18
192.168.42.129	TRUST	17

Destination Ip: 192.168.42.133

Optimal Path: (With no Malicious IPs)

192.168.42.128,192.168.42.129,192.168.42.133

ServiceId	RouteInfo
8677	192.168.42.128,192.168.42.129,192.168.42.133
8677	192.168.42.128,192.168.42.130,192.168.42.133
8677	192.168.42.128,192.168.42.130,192.168.42.129,192.168.42.133
8677	192.168.42.128,192.168.42.129,192.168.42.130,192.168.42.133

Figure 5.5: Computation of Optimal path

- In route log, the possible path from source to destination is displayed.
- The path which gives the first acknowledgement is considered as the optimal path and is displayed in the optimal path checkbox.

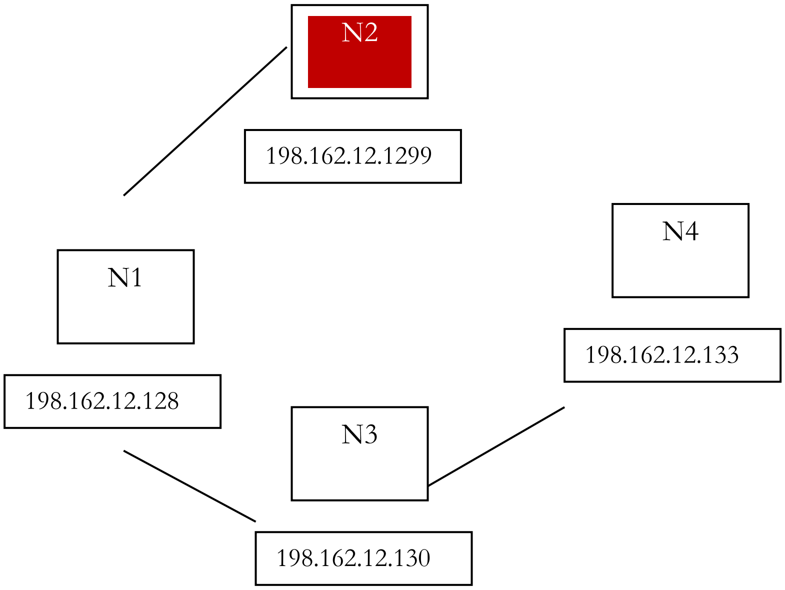
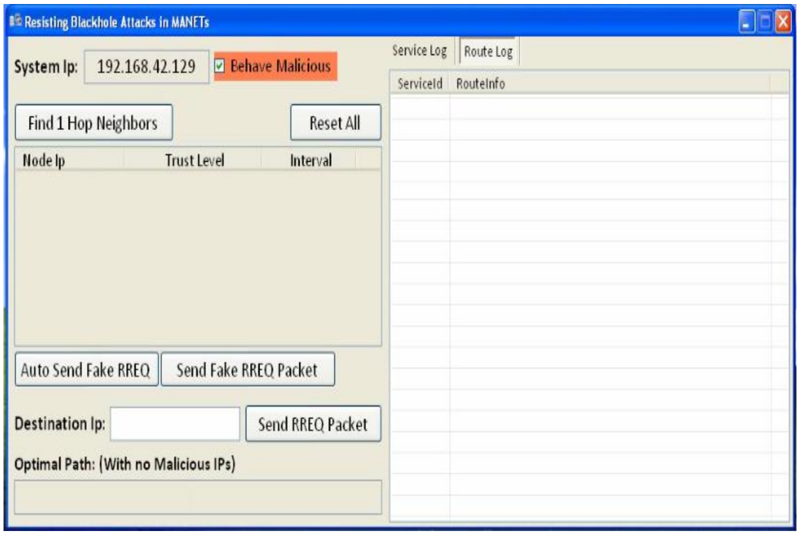


Figure 5.6: Network topology for case 2.

- In case 2, N2 is considered as malicious.
- There is no direct path from N1 to N4, N2 to N3, N2 to N4.

- N1 is considered as source node , N4 is considered as destination node



System Ip: 192.168.42.129 ☑ Behave Malicious

Node Ip	Trust Level	Interval

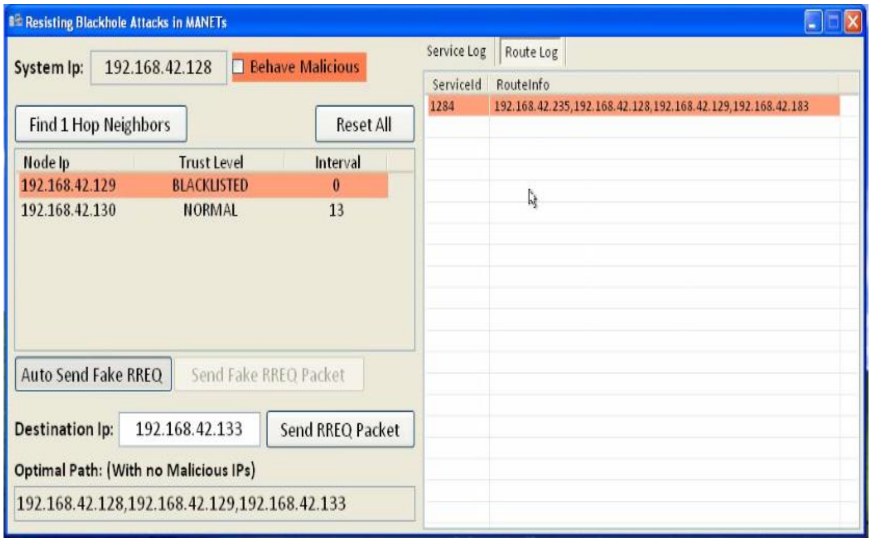
Destination Ip:

Optimal Path: (With no Malicious IPs)

ServiceId	RouteInfo

Figure 5.7: Marking node 2 as malicious

- Node 2(N2) is marked as malicious.



System Ip: 192.168.42.128 □ Behave Malicious

Node Ip	Trust Level	Interval
192.168.42.129	BLACKLISTED	0
192.168.42.130	NORMAL	13

Destination Ip: 192.168.42.133

Optimal Path: (With no Malicious IPs)

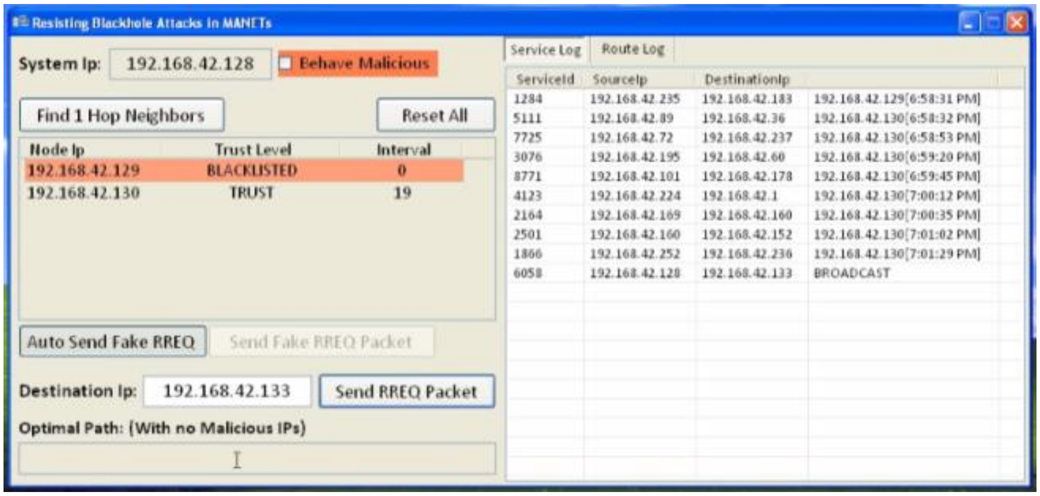
192.168.42.128,192.168.42.129,192.168.42.133

ServiceId	RouteInfo
1284	192.168.42.235,192.168.42.128,192.168.42.129,192.168.42.183

Figure 5.8: 1-hop neighbour identification

- Inorder to identify the neighbour nodes in the network topology, 1-hop neighbour identification using HELLO exchange mechanism is used.
- The source node(N1) identifies its neighbour's as N2 and N3 by clicking on Find on 1 hop neighbour.
- After identifying neighbour's of source node, to send a fake RREQ packets, Auto send fake RREQ is enabled and the interval is changed.
- The fake RREQ packets are sent in the interval between MIN NORMAL 30S and MAX NORMAL 90s.

- In the service log, the fake packet's service id, source IP and destination IP is displayed.
- The node(N2) which gives RREP to a fake RREQ sent by N1 is considered as malicious and its trust level is set as blacklist.
- Any reply from malicious node is discarded.



Resisting Blackhole Attacks in MANETs

System Ip: 192.168.42.128 □ Behave Malicious

Node Ip	Trust Level	Interval
192.168.42.129	BLACKLISTED	0
192.168.42.130	TRUST	19

Destination Ip: 192.168.42.133

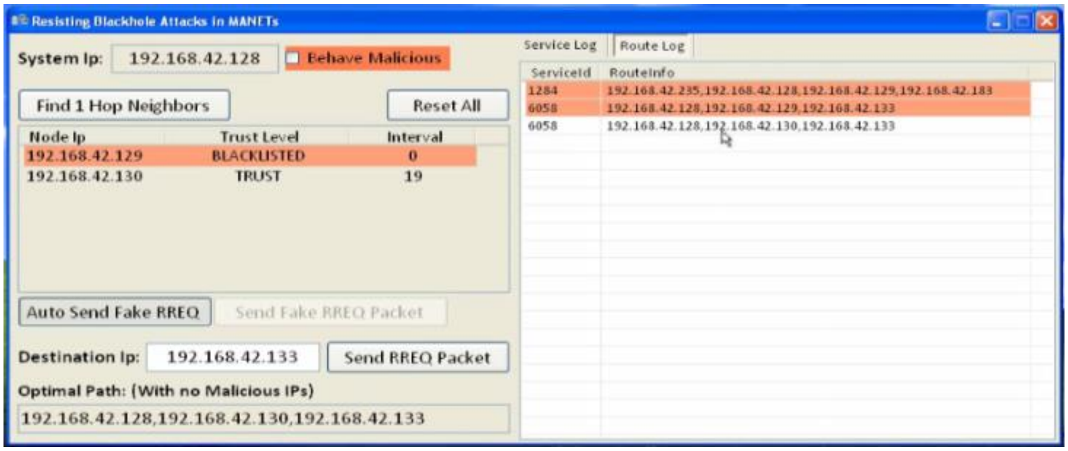
Optimal Path: (With no Malicious IPs)

Service Log

ServiceId	SourceIp	DestinationIp	
1284	192.168.42.235	192.168.42.183	192.168.42.129[6:58:31 PM]
5111	192.168.42.89	192.168.42.36	192.168.42.130[6:58:32 PM]
7725	192.168.42.72	192.168.42.237	192.168.42.130[6:58:53 PM]
3076	192.168.42.195	192.168.42.60	192.168.42.130[6:59:20 PM]
8771	192.168.42.101	192.168.42.178	192.168.42.130[6:59:45 PM]
4123	192.168.42.224	192.168.42.1	192.168.42.130[7:00:12 PM]
2164	192.168.42.169	192.168.42.160	192.168.42.130[7:00:35 PM]
2501	192.168.42.160	192.168.42.152	192.168.42.130[7:01:02 PM]
1866	192.168.42.252	192.168.42.236	192.168.42.130[7:01:29 PM]
6058	192.168.42.128	192.168.42.133	BROADCAST

Figure 5.9: Route discovery transmission

- To select the optimal route between original source(N1) and original destination(N4) which is free from identified malicious nodes, DSR(Dynamic Source Routing) protocol is used.
- After entering destination IP address , to broadcast original packet to destination, send RREQ packet checkbox is enabled.



Resisting Blackhole Attacks in MANETs

System Ip: 192.168.42.128 □ Behave Malicious

Node Ip	Trust Level	Interval
192.168.42.129	BLACKLISTED	0
192.168.42.130	TRUST	19

Destination Ip: 192.168.42.133

Optimal Path: (With no Malicious IPs)

192.168.42.128,192.168.42.130,192.168.42.133

Route Log

ServiceId	RouteInfo
1284	192.168.42.235,192.168.42.128,192.168.42.129,192.168.42.183
6058	192.168.42.128,192.168.42.129,192.168.42.133
6058	192.168.42.128,192.168.42.130,192.168.42.133

Figure 5.10: Optimal path computation

- In route log, the possible path from source to destination is displayed.
- The path which contains malicious node is discarded.

- The path which gives the first acknowledgement is considered as the optimal path and is displayed in the optimal path checkbox.

5 CONCLUSION

This paper introduces enhanced BRM[blackhole resisting mechanism]concept in which each node is responsible for monitoring the behaviour of its neighbor nodes to detect malicious node and to exclude them. And also introduces a concept of modified Self Protocol Trustiness[SPT], in which it will send a fake RREQ at random interval of time to detect if any misbehave. With the help of Dynamic Source Routing[DSR] protocol the optimal path will be identified between any original source and destination which is free from identified malicious nodes. The proposed mechanism did not use cryptographic techniques which results in consumption of power and computation resources. Furthermore, the mechanism did not require any additional packets and hence does not incur any additional overhead. The proposed mechanism will detect any number of malicious node within a short duration of time.

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