International Journal of Soft Computing and Engineering (IJSCE)
ISSN: 2231-2307 (Online), Volume-13 Issue-1, March 2023

Secure and Light Weight Aodv (Slw-Aodv) Routing Protocol for Resilience Against Blackhole Attack in Manets

M V D S Krishna Murty, Lakshmi Rajamani

Abstract*: This paper aimed at the detection of blackhole attacks and proposed a new method called as Secure and Light Weight Adhoc On demand Distance Vector Routing (SLW-AODV). SLW-AODV is an extended version of the traditional AODV routing protocol. The proposed SLW-AODV ensures resilience for both blackhole and cooperative blackhole attacks. It employs a simple Challenge, Response and Confirm (CRC) strategy with chaotic maps for the identification of both blackhole and cooperative blackhole attacks. SLW-AODV identifies the attacked nodes at both route discovery and data forwarding process. For experimental validation, we have conducted extensive simulations and the performance is validated through Packet Delivery Ratio, Throughput and Average end-to-end delay. The obtained performance metrics shows an outstanding performance than the state-of-the art methods.

***Keywords*: Average End-To-End Delay, Chaotic Maps, Cooperative Blackhole, MANETs**

I. INTRODUCTION

Mobile Adhoc networks (MANETs) are one of the wireless networks formed with the mobile devices as nodes. Due to the nature of decentralized communication, MANETs gained huge interest in different applications including emergency rescue operations, military operations, collaborative distributed computing, disaster management and some personal area network applications [1]. In MANETs, there exists mobile nodes which don't have any fixed infrastructure and can communicate with each other through multiple hops. Since MANET is characterized as a decentralized network, communication between any two nodes requires multi-hop relays to act as routers. Every node in MANET is permitted to move arbitrarily in the network. In a MANET, all nodes are treated equivalently and so every node has the ability to transfer data between any source and destination pairs. However, the major issues in MANETs are their varying mobility nature which consequences to serious link failures, network security and quality of services challenges for researchers [2-4]. Due to the dynamic nature of MANETs and their lack of fixed infrastructure, they are generally vulnerable to several types of attacks. These attacks include sinkhole, DoS (Denial of Service), DDoS (Distributed DoS), and blackhole attacks. For example, Kalita *et al.* [5] surveyed different types of attacks associated with ad hoc networks and provided countermeasures for these attacks. Nguyen and Nguyen [6] introduced the impact of different types of attacks associated with MANETs based on a simulation study. Among the several attacks, blackhole attack is a major attack which causes serious damage to the network. Panos *et al.* [7] presented a comprehensive analysis of the blackhole attack (BHA) related to MANETs. In addition, they introduced the blackhole intensity as a new attack factor and evaluated its impact on the network performance. Khanna and Sachdeva [8] presented different aspects of blackhole attack together with the weaknesses of current literature. In addition, they introduced comprehensive classifications of the mitigation and detection schemes along with reviewing and also comprising several published work associated with those classifications. Even though several methods are proposed for blackhole attack identification in MANETs, no method was concentrated on the determination of cooperative blackhole attacks as well as on the nodes attacked by blackhole attack during data forwarding process. Hence, this paper proposes a simple and effective mechanism called as Secure and Light Weight AODV (SLW-AODV) for both blackhole and cooperative blackhole attacks detection. SLW-AODV is an extended version of the traditional AODV routing protocol. SLW-AODV follows a three-phase mechanism called as Challenge-Response-Confirm (CRC) to discover a route with no blackhole attacked nodes. The SLW-AODV can detect malicious nodes that behave abnormally during the route discovery process along with the malicious node that behaves normally during the routing process but behaves maliciously during the forwarding process. The remaining paper is organized as follows; section II explores the literature survey on blackhole detection methods. Section III explores the details of proposed SLW-AODV. Section IV explores the details of simulation experiments and the final section concludes the paper.

II. LITERATURE SURVEY

In this survey, we have explored different earlier methods those were mainly aimed for the detection of blackhole attacks in MANETs. S.

Manuscript received on 08 February 2023 | Revised Manuscript received on 13 February 2023 | Manuscript Accepted on 15 March 2023 | Manuscript published on 30 March 2023.

*****Correspondence Author(s)
M V D S Krishna Murty*, Research Scholar, Department of Computer Science and Engineering, Jawaharlal Nehru Technological University Hyderabad (Telangana), India. E-mail: mkrishnamurty@gmail.com, ORCID ID: https://orcid.org/0000-0002-4705-3818
Dr. Lakshmi Rajamani, Professor and Head (Retd), Department of Computer Science and Engineering, Osmania University, Hyderabad (Telangana), India. E-mail: drlakshmiraja@gmail.com

Sharma et al. [9] employed a new routing protocol called as secure zone routing protocol (SZRP) to provide resilience to MANETs against BHA. In this approach, the author assumed the BHA inside and outside of zones i.e. internal and external BHAs. They used Qualnet for simulation purpose.

C. Jiwen et al. [10] adapted cross layer design and aimed at the detection of BHA and Grey Hole Attacks (GHA). In the proposed method they proposed to overhear based path selection mechanism about the activity of next hop node. Moreover they used internal HELLO packets and saved their energy resource at the detection of BHA. Further, to reduce false positive rate under larger network load, this approach adapted a reporting system based on collision rate in Medium Access Control (MAC) layer. They referred the standard Dynamic Source Routing (DSR) protocol and used NS-2 for simulation.

Y. F. Alem, Z. C. Xuan [11] proposed an anomaly detection based intrusion detection (ADID) mechanism to identify BHA over both single and multiple mobile nodes in MANETs. Tamilarasan [12] proposed a new algorithm called as Prior Receive Reply (PRR) algorithm or counter algorithm to prevent nodes from BHA in MANETs. Haas, Z. J[13]proposed a new routing protocol, Zone Routing Protocol (ZRP), for reconfigurable wireless networks. The novelty of the ZRP protocol is that it is applicable to large flat-routed networks and the performance showed reduction in the number of control messages, as compared with other reactive schemes. A. Tripathi and A. K. Mohapatra [14] proposed to measure hop count for BHA detection. The hop count is measured based on packet confirmation. However the major disadvantage is that they didn't involve destination sequence number at the detection of BHA.

T. N. D. Pham and C. K. Yeo [15] proposed a method called as statistical based BHA and GHA detection to detect two types of attacks in MANETs they are collusion and individual attacks. Here, the nodes exchange their history such that they can analyze the forwarding behavior. To classify as normal nodes from attacker nodes, they suggested a new metric called as Forwarding Ratio (FR). FR helps in BHA and GHA identification as the attackers are required to create a frequent fake encounter record in a very huge number to drop the message continuously. In such case FR value will be very low for individual attacker nodes. Hence proposed the mechanism by involving sent message count and uneven pattern of appearance frequency in routing algorithm to identify colluding attacks.

A. M. El-Semary and H. Diab [16] proposed BH protected AODV (BP-AODV) routing to solve the BHA related security issues in MANETs. This approach is an extended version of AODV which involves some randomly generated challenges at route discovery process. Moreover this approach also aimed at the detection of BHA and coordinating nodes which combinly launch BHA in MANETs. They employed secret maps generation to ensure resilience against BHA in MANETs.

S. Shrestha et al. [17] proposed change in control packet sequence number especially in RREP to provide protection for nodes of MANETs from BHA and reducing the loss of data packets. E. Elmahdi et al [18] proposed a homomorphic encryption scheme in AOMDV protocol to ensure a reliable and secure data transmission in MANETs under BHA. They observed that their method has better detection performance than the AOMDV when there are a large number of malicious nodes in the network.

N. G. Wakode [19] proposed a Cooperative Bait Detection (CBA) approach for malicious node identification using AODV. CBA is referred as both reactive and proactive approach and applied a simple mechanism called as reverse tracing for the detection of BHA. S. Pandey and V. Singh [20] applied machine learning algorithms such as Artificial Neural Network (ANN) and Support Vector Machine (SVM) for BHA detection in MANETs. G. Li, Z. Yan and Y. Fu [21] used NS-3 simulator to study and analyze the impact of BHA in AV protocol. They analyzed three performance metrics namely packet loss rate, end-to-end delay, and throughput. Further they analyzed BHA impact on these metrics at different network parameters like speed, number of nodes and number of blackhole attacked nodes in the network.

V. Sharma et al. [22] analyzed the TCP over BHA. They performed a detailed analysis of reliability of transport layer protocol at several conditions. The impact is measured through end-to-end delay, normalized routing load and throughput. S. Kaushik etal.[23] used SVM algorithm to analyze the performance of a AODV and SAODV for communication and packets transfer among nodes in Mobile Adhoc Networks. The analysis is carried out through several performance metrics including end-to-end delay, packet delivery ratio, throughput and average energy consumption. They designed a methodology with the help of learnings from the estimations and computations done at the time of transfer of packets between nodes in the network. S. Barai and P. Bhaumik [24] proposed an extended version of conventional Spray and Wait Routing (SWR) protocol to reduce the impact of BHA on network performance. T. Terai et al [25] detected that blackhole can predict the sequence numbers present in the control packets and can manipulate them to launch in the network. To overcome this problem they proposed a detection and prevention mechanism, based on the local data exchange between nodes in the network.

M. B. M. Kamel et al [26] proposed a secure and trust-based mechanism based AODV (STAODV) to isolate malicious nodes in MANETs and to improve the security of AODV protocol. They linked a trust value for each node to estimate the trust level of that node. They proposed to analyze each incoming packet to prevent BHA. I. Kaushik [27] developed an intrusion detection system through NS-2 after analyzing different attacks at different layers. They concluded that BHA is one of the serious attacks and applied intrusion detection system over it. F. Taranum et al. [28] applied Elliptical Key Cryptography (ECC) and reverse AODV (R-AODV) to detect BHA and to ensure a secure data transmission in MANETs. They mainly aimed to keep the packets secure. When compared to public key encryption algorithms, ECC is simple as it provides key with smaller size. Moreover ECC eliminates the necessity of Pre-Key distribution and ensures secure parths against BHAs in MANETs.

III. PROPOSED FRAMEWORK

3.1 Overview

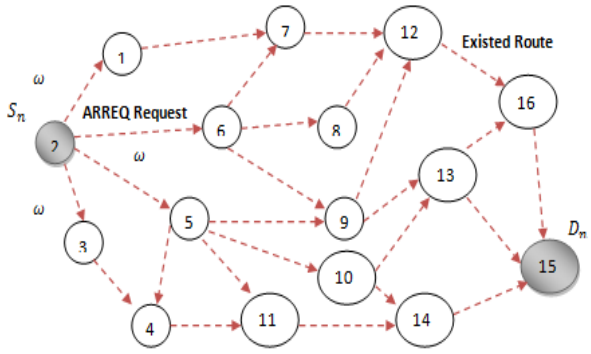
The main contribution of SLW-AODV is to address the cooperative blackhole attack associated with t AODV protocol along with providing a routing protocol that is robust against blackhole attack and cooperative blackhole attack during the routing process. SLW-AODV protocol uses a Challenge-Response-Confirm (CRC) pattern to establish trusted routes. Initially the source node (S_n) generates a challenge value and then conveys it to a destination node during a route request process. When the destination receives the challenge, it computes the corresponding response as a function of the received challenge along with other secret values generated by the destination. The destination node propagates the response value to the source during the route reply process while it keeps the secret values. Finally, the destination node confirms the route by conveying the secret values during the route confirm process. The SLW-AODV accomplishes its task by incorporating chaotic map into its design along with using Challenge-Response-Confirm pattern during routing process.

3.2. Message Types

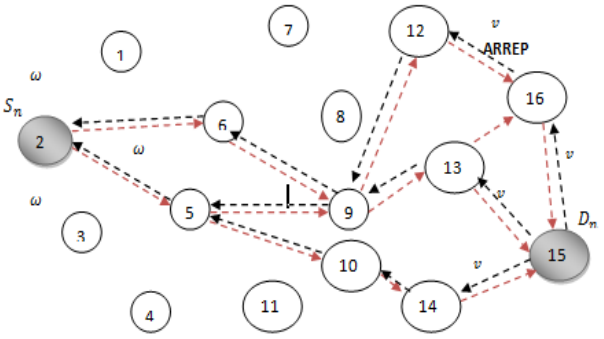
SLW-AODV uses five types of messages. They are - ARREQ (Altered Route REQuest), ARREP (Altered Route REPly), RERR (Route ERRor), HELLO (HELLO), and RC (Route Confirm). SLW-AODV altered the RREQ and RREP while it used HELLO and RERR of AODV protocol as it is. Alongside, SLW-AODV creates a new message called as Route Confirm (RC). ARREQ is extended version of RREQ just by extending two fields to include two values; they are challenge (ω) and timestamp (τ). ω is a challenge value generated by source node and τ is the time at which ω is generated. Next ARREP is an extended form of RREP by extending one field to include a response value v generated by D_n. Finally RC packet has 8 fields which convey several secret values generated by D_n at the time of RC process.

3.3 SLW-AODV Routing Process

SLW-AODV provides protection for MANETs against BHA and CBHA. Also, SLW-AODV is capable of identifying BHA at data forwarding process. The major difference between AODV and SLW-AODV is that SLW-AODV is extended RD process of AODV to execute the RC mechanism. Moreover, unlike AODV which creates only one route, the proposed SLW-AODV establishes three routes for a given source and destination node pair. The proposed SLW-AODV completes the route establishment process in three steps. They are- 1) Request, 2) Reply, and 3) Confirm. To explain the process of SLW-AODV, a network of 16 nodes is created as shown in Figure.1. It is assumed that Node 2 is source and Node 15 is destination. Since SLW-AODV is a reactive protocol, S_n starts RD when it wants to send data to D_n. At this stage S_n generates a challenge value w and conveys it to the nodes. Further S_n creates ARREQ by putting w and hop count (h_c) and broadcast ID (b_{id}) in the respective fields of ARREQ. Then S_n broadcasts ARREQ and receives at nodes 1, 3, 5 and 6. According to Figure.1(a), when ARREQ is received at an intermediate node it checks first whether the current ARREQ is received from the same node previously or not. Also, it checks the total ARREQ count whether it is more than three or not from different nodes. If the above situations have not happened then it performs 4 steps. They are- 1) Increases the count of ARREQ's received, 2) Establishes a reverse route to S_n via forwarding node. 3) Routing table is updation with the challenge value, 4) Increments the hop count, if the node at which the ARREQ was received is not a D_n and then rebroadcasts the ARREQ again to its neighbour nodes. The important point to note is that SLW-AODV allows three routes through three different nodes to S_n. The above procedure is repeatedly performed by neighbour nodes until ARREQ reaches D_n. Upon receiving ARREQ, the D_n starts reply process.

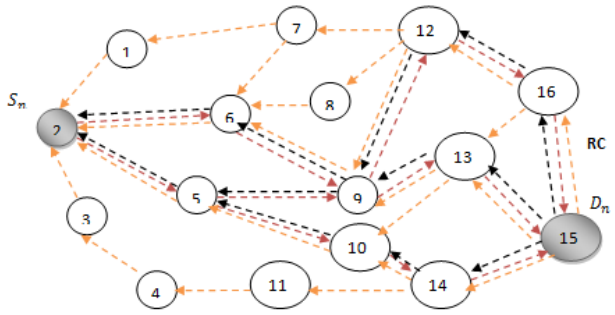


(a)



(b)

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)



(c)

Figure.1 SLW-AODV routing process

On the destination side,reply process commences immediately after receiving first ARREQ. At this phase, it generates a response value *v* and propagates to the neighbour nodes present on the routes through which the ARREQ is received. Further the SLW-AODV allows up to three ARREQs from three different nodes and each neighbour node can receive three reply packets. While receiving ARREQ, D_n performs 4 steps. They are, 1) If D_n observed that the same ARREQ is received in the past, it skips the step and starts directly the second step otherwise destination node compares response value according to Eq.(1).

$$v = \lfloor x(\zeta) \rfloor \quad (1)$$

Where $\lfloor . \rfloor$rounds the argument present in it and $x(\zeta)$ is a Logistic Chaotic map [87], [88]. Mathematically it is calculated as

$$x(\zeta) = \mu x(\zeta - 1)[1 - x(\zeta - 1)] \quad (2)$$

Where ζ is secret value generated by D_n randomly and it represents the total number of iterations. μ is the control parameter and $x(0)$ is the initial value of Logistic map. The mathematical representation of μ and $x(0)$ is formulated through two random numbers generated by destination nodes. They are r_{m1} and r_{m2}.

$$x(0) = \frac{\omega}{r_{m1}} \text{mod} 1 \quad (3)$$

$$\mu = \frac{\omega}{r_{m2}} \text{mod} 1 \quad (4)$$

Note that Eq.(3) and Eq.(4) generate $x(0)$ and μ respectively within their valid ranges thereby the calculated chaotic maps explore significant features of applied map. Both the equations include the challenge generated by $S_n$such that the source gets an awareness about the D_n. Moreover the generation of these values is totally dynamic in nature and they are totally dependent on the nodes serving as S_n and D_n. Hence the corresponding $S_n$and D_n will get a distinct chaotic maps which provide more security.

The major advantage with the Logistic map is that its wide employment in general applications to provide security for multimedia contents. Moreover the Logistic map has excellent features like randomness, ergodicity and sensitive to control parameters and initial situations. The dynamicity of control parameters add additional layer of security . Hence the use of chaotic maps provides more security to the proposed method. Next, the time is updated at D_n according to the following expression-

$$t = {\sum_{i=1}^{n}(t_{ri} - \tau)}/{2n} \quad (5),$$

where τ denotes the time instance at which the chaotic map is generated while t_{ri} is the time instance of the i^{th} ARREQ received by D_n. *n* denotes the total ARREQ's account with similar broadcast ID. Here, the maximum value of n is allowed up to 3 (i.e., $1 \leq n \leq 3$). Next, D_n generates an ARREP by including the response value along with the secret values used to produce response value such as r_{m1}, and r_{m2}. Then, ARREP is unicasted by D_n to its neighbour nodes, i.e., the node through which the ARREQ is obtained at D_n. In this case, as shown in Figure.1(b), the request that unicasted by $D_n$will be received at nodes 13, 14, and 16.

Upon receiving the ARREP at any intermediate node, it executes mainly 4 steps. At first, it creates a reverse route to D_n via the forwarding node. At this phase, every node is allowed to establish maximum of 3 routes to D_n (for example in Figure.1(b), node 9 can establish two reverse routes through node 12 and node 13 to D_n). Secondly, the intermediate nodes keep every route in the waiting state i.e the route cannot be allowed to use until unless it would get confirmation by the D_n. A route will get into an operational state after getting confirmed by confirmation process initiated by the D_n. Thirdly, the intermediate node fetches the response value *v* from ARREP and updates it in its routing table.

Fourthly, if S_n receives ARREP, it simply

ignores it otherwise the intermediate node performs unicast of every obtained ARREPs with similar response value to S_n

over different routes (according to Figure.1(b),if node 9 obtains the replies with same response value then it performs unicasting of one ARREP through node 12 and another through node 13). If response values of ARREPs are different then the node unicasts them via the same forwarding node. At last , D_n starts the confirmation process whenever it

founds time reaches to zero value. At the confirmation round, the proposed SLW-AODV performs three steps, they are- 1) The secret value generated by destination node such as ζ,

r_{m1}, and r_{m2} are revealed to neighbour nodes, 2) Malicious

nodes those have tendency to compromise with BHA and CBHA are identified, 3) Routes with malicious nodes are discarded and information is propagated to entire work.

When D_n founds that time reaches to zero value, it creates a route confirm message with 8 fields and keeps the secret values such as ζ, r_{m1}, and r_{m2} into it. Next, the route confirm is broadcasted by D_n as shown in Figure.(b) and it receives at node 13, 14, and 16. Upon receiving the route confirm at any node which is not a part of the route within the specific time period, it performs a comparison between the corresponding values of ζ, r_{m1}, and r_{m2}. If, most of the route conformation messages are having similar values, then the node rebroadcasts only few RCs which have major similarity. If the count of response values present in the RC message is neutral, then the intermediate nodes neglect those messages. On the other hand if the route confirmation messages that were received at a node which lies on the route (ex. 16, 14 13, 12, 10, 9, 6 and 5) from different nodes in the particular time period, then that node executes majorly five steps- 1) Calculate response value as per Eq.(1) for every RC with the help of secret values present in it such as ζ, r_{m1}, and r_{m2} and *w*. 2) Compare the response values with each other and get the most matched value. Let it be denoted as v_m, 3) v_m is compared with all v_i values those were linked with different routes in the routing table, 4) If the node founds that v_m and v_i are the same, then it triggers i^{th} route into operational state otherwise the node declares the respective node linked with route is not trustworthy and it is having malicious nature. Further the corresponding node is removed from the routing table of the i^{th} route. Finally, if the intermediate node is not S_n,it broadcasts the RC message to its next hop neighbour nodes to find the one with maximum match otherwise $S_n$initiates the data packets transmission to D_n.

IV. EXPERIMENTAL ANALYSIS

This section presents a set of conducted experiments that compares the performance of the proposed SLW-AODV protocol against 4 methods namely AODV, Modified Sequence Number AODV (MSN-AODV) [17], Cooperative Prevention Method AODV (CPM-AODV) [25], and Reverse AODV (RAODV) [28] protocols under cooperative blackhole attack.

4.1. Simulation set up

In the simulation set up, we have created a network and the number of nodes chosen is varied from 20 to 60. The area of network is considered as 1000*1000 m^2. For every simulation, the mobile nodes are deployed randomly and their positions are not related with the positions of earlier simulation study. The transmission range is varied from 10% to 25% of network area, i.e., 100, 150, 200, and 250 and the average speed of mobile node is altered from 5 m/s to 25 m/s. On an average, the source node generates 10 packets per second and the packet size is assumed as 512 kilo bytes. Table.1 shows the simulation set up details.

Table.1 Simulation set up

Network parameter	Value
Number of nodes	20-60
Area of Network	1000*1000 m^2
Transmission Range	10% to 25% of network area
Average Node Speed	5 m/s to 25 m/s
Traffic Type	Constant Bit Rate (CBR)
Data packets	10
Simulation Time	200 Seconds
Size of data packets	512 kilobytes

4.2 Performance Metrics

The performance is measured in terms of Throughput, Packet Delivery Ratio (PDR), and end-to-end delay (E2ED). The formal definitions of these metrics are given below;

Throughput: It is the amount of data received in a given time period and it is usually measured in bits per second. The throughput metric explores the amount of productivity that reached to the destination node and sent by the source node. Mathematically, the throughput is measured as

$$Throughput = \frac{Number\ of\ packets\ received \times 8}{(t - t_f)} \quad (6)$$

Where t_f is the time at which the first packet received, and t is the time at which the last packet received or the simulation time when the session is not completed. Here packets received are in kilobytes and time is in seconds and hence the unit of Throughput is Kilobytes per second (Kbps).

PDR: It is the ratio of number of packets received to the number of packets sent by destination and source nodes respectively. PDR is measured for a link and also for a path. To know the quality of a link, the PDR is measured at the link which is a connection between only two nodes whereas for a path the PDR occurred at individual links is summed up and divided by the total number of links over a particular path. Mathematically, PDR is measured as

$$PDR = \frac{P_r}{P_s} \times 100 \quad (7)$$

Where P_s is total number of packets sent and the P_r is total number of packets received.

E2ED: It is the time that a packet takes from its source until reaching its destination. Average E2ED (AE2ED) referrers to the combination of delays namely propagation, buffering, queuing, and retransmission. Mathematically, AE2ED is measured as

$$AE2ED = \frac{1}{p}\sum_{j=1}^{p} Delay(j) \quad (8)$$

Where P is total packet count, $Delay(j)$ is the propagation delay of a packet j and measured as the difference of two successive time instants i.e. packet received time at destination node and the packet transmitted time at the source node.

4.3 Result Analysis

The performance of proposed SLW-AODV protocol is validated by conducting several simulation experiments by considering Throughput (kbps), AE2ED (sec), and PDR (%) for blackhole attack and cooperative blackhole attack. The results of Throughput in Figure.2, AE2ED in Figure.3, PDR in Figure.4 shows the blackhole attack for a malicious node for all methods with respect to simulation time.

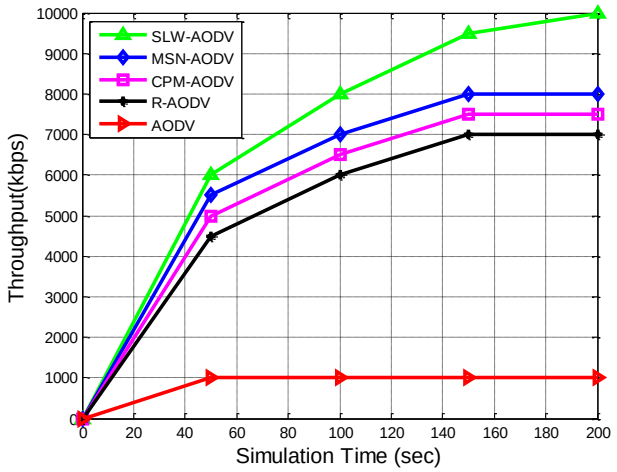


Figure. 2 Throughput (kbps) for Varying Simulation Time (Sec) Under Blackhole Attack

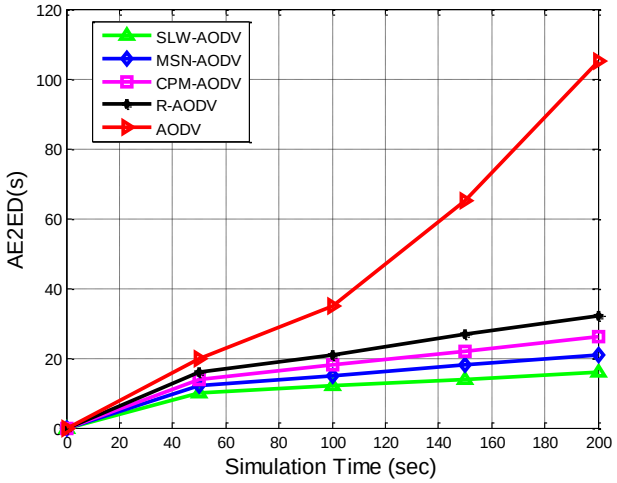


Figure. 3 AE2ED(s) for Varying Simulation Time (Sec) Under Blackhole Attack

As simulation time increases the throughput also increases gradually for the methods as shown in figure.2. There is no proper security mechanism for AODV protocol to tackle the blackhole attack compared to remaining methods. So throughput of AODV protocol is very less. Throughput of proposed SLW-AODV protocol is high because it is able to identify the malicious nodes efficiently as it employed Challenge-Response-Confirmation strategy which is not available in the conventional methods. Thus, the throughput of proposed method is 6700kbps whereas it is 5700kbps, 5300kbps, 4900kbps, and 800kbps for MSN-AODV, CPM-AODV, R-AODV, and AODV respectively.

Figure.3 shows the variation of AE2ED of the considered methods with respect to simulation time. As simulation time increases AE2ED also increases. When conventional AODV protocol attacked with blackhole attack, it drops the packets due to the lack of security mechanism provision. Hence data transmission is delayed and AE2ED is high in conventional AODV protocol. When this type of attack occurs in the proposed method, it chooses three alternate ways to redirect data packets towards the destination. So, the delay is reduced in the proposed method when compared to the existing methods. AE2ED of proposed method is 10.4sec whereas it is 13.2sec, 16.4sec, 19.2sec, and 45sec for MSN-AODV, CPM-AODV, R-AODV, and AODV respectively.

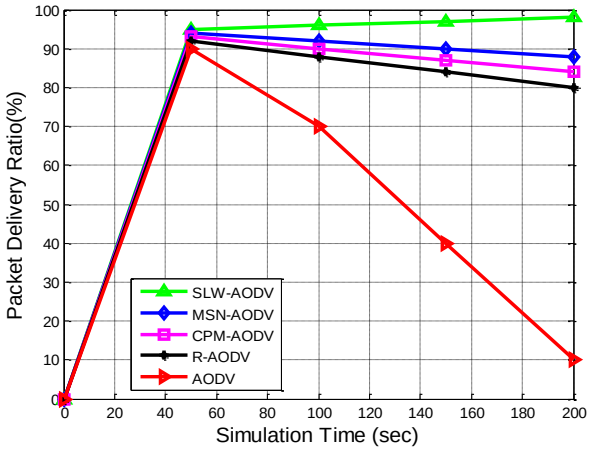


Figure. 4 Packet Delivery Ratio (%) for Varying Simulation Time (Sec) Under Blackhole Attack

Figure.4 shows the variation of PDR of the considered methods with respect to simulation time. As simulation time increases PDR also increases. To route the data packets towards the destination, the proposed method uses efficient routing mechanism such as Challenge-Response-Confirmation strategy. The conventional methods are more vulnerable to blackhole attack and they drop the packets in the middle. So, initially all the packets are forwarded successfully towards the destination and when the attack occurs, the conventional methods drop the packets in the middle and hence PDR decreases. Thus, PDR of proposed method i.e SLW-AODV is 77.2% whereas it is 72.8%, 70.8%, 69% for MSN-AODV, CPM-AODV, R-AODV respectively and for AODV, it is 42% because AODV has not got any mechanisms to detect either blackhole attack or cooperative blackhole attack.

Retrieval Number: 100.1/ijsce.A35920313123
DOI: 10.35940/ijsce.A3592.0313123
Journal Website: www.ijsce.org

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

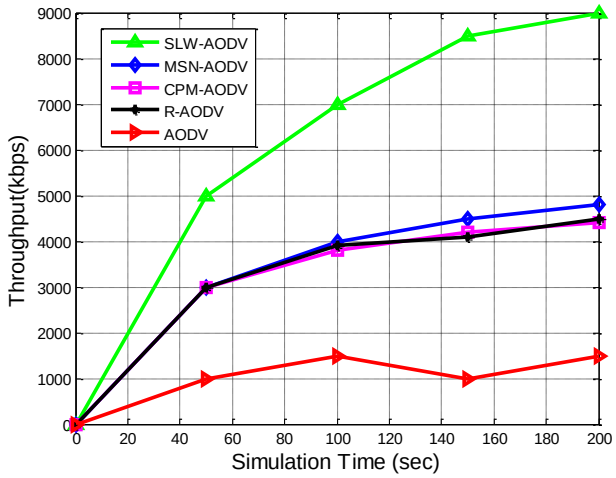


Figure.5 Throughput (kbps) for varying simulation time (sec) under cooperative blackhole attack

Figure.5, Figure.6, and Figure.7 show the performance of five protocols under the cooperative blackhole attack. Figure.5 shows the throughput measurement with respect to simulation time. As simulation time increases throughput of the network also increases. The data packets are forwarded through malicious nodes. The existing methods such as R-AODV, CPM-AODV, and MSN-AODV drop the packets in the middle whereas the proposed method is able to select the alternate paths to forward the data packets towards the destination. Hence the throughput in the proposed method is high when compared to the existing methods. The conventional AODV method suffers from security provision so the throughput decreases rapidly as simulation time increases. Thus, the throughput of proposed method is 5900kbps whereas it is 3260kbps, 3080kbps, 3100kbps, and 1000kbps for MSN-AODV, CPM-AODV, R-AODV, and AODV respectively.

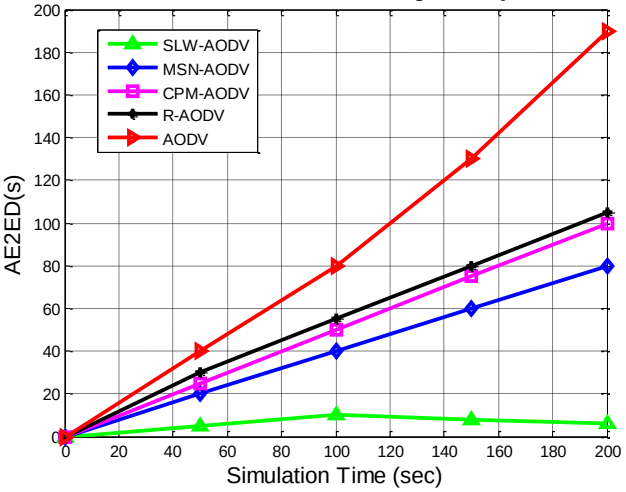


Figure.6 AE2ED (sec) for Varying Simulation Time (Sec) Under Cooperative Blackhole Attack

Figure.6 shows the measurement of AE2ED for five protocols with respect to simulation time. From the figure.6, it is known that as simulation time increases the AE2ED also increases. When the data packet is forwarded through the malicious nodes, the conventional AODV protocol immediately drops the packets and it is not able to forward the packets to the destination. In such case, the proposed method chooses an alternate path to forward the data packets towards the destination. So, as the simulation time increases the packet forwarding can be delayed in conventional AODV protocol when compared to the proposed method. Thus, AE2ED of proposed method is 5.8sec whereas it is 40.3sec, 50.5sec, 54.5sec, and 88.3sec for MSN-AODV, CPM-AODV, R-AODV, and AODV respectively.

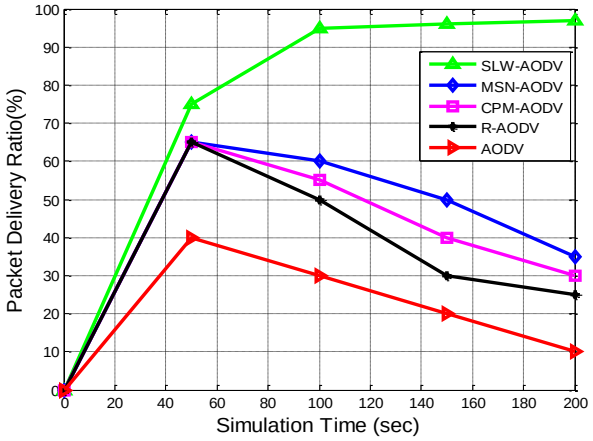


Figure.7 PDR (%) for Varying Simulation Time (Sec) Under Cooperative Blackhole Attack

Figure.7 shows the measurement of PDR for five protocols with respect to simulation time. From figure.7, it can be observed that as simulation time increases the PDR decreases. The proposed method efficiently detects malicious nodes and when attack occurs, it chooses various alternate paths to forward the data packets without any drop of packets. However, the conventional AODV protocol drops the packets in the middle of transmission and hence the PDR reduces. Thus, the PDR of proposed method is 72.6% whereas it is 42.3%, 48.5%, 44.3%, and 20.2%for MSN-AODV, CPM-AODV, R-AODV, and AODV respectively.

V. CONCLUSION

This paper introduced a simple and effective SLW-AODV protocol to protect a MANET from blackhole and cooperative blackhole attack. The SLW-AODV protocol uses a Challenge-Response-Confirm pattern to establish trusted routes and it employs 5 types of messages and efficient routing process to transfer the data packets. The performance of proposed method is validated through the metrics viz. Throughput, AE2ED, PDR under blackhole and cooperative blackhole attack. When compared to the considered methods viz. MSN-AODV, CPM-AODV, R-AODV and AODV, the proposed method i.e SLW-AODV has performed very well and results for Throughput, AE2ED, PDR show its superiority.

ACKNOWLEDGEMENT

Authors acknowledge the immense help received from the scholars whose articles are cited and included in references of this paper. The authors are obliged to authors/editors/publishers of all those articles, journals and books from where the literature of this paper has been reviewed.

DECLARATION

Funding/ Grants/ Financial Support	No, I did not receive.
Conflicts of Interest/ Competing Interests	No conflict of interest to the best of our knowledge.
Ethical Approval and Consent to Participate	No, the article does not require ethical approval and consent to participate with evidence.
Availability of Data and Material/ Data Access Statement	Not relevant.
Authors Contributions	Conceptualization, software, methodology, validation, formal analysis, investigation, M V D S Krishna Murty; writing—original draft preparation, M V D S Krishna Murty; writing—review and editing, M V D S Krishna Murty, Lakshmi Rajamani;

REFERENCES

1. G. A. Walikar, R. C. Biradar, A survey on hybrid routing mechanisms in mobile ad hoc networks, *Journal of Network and Computer Applications*, 77 (2017) 48-63. [CrossRef]
2. M. K. Gulati, K. Kumar, A review of QoS routing protocols in MANETs, *in: 2013 International Conference on Computer Communication and Informatics*, 2013, pp. 1-6. [CrossRef]
3. M. M. Alani, Manet security: A survey, *in: 2014 IEEE ICCSCE*, 2014, pp. 559-564. [CrossRef]
4. M. Amadeo, C. Campolo, A. Molinaro, Forwarding strategies in named data wireless ad hoc networks: Design and evaluation, *Journal of Network and Computer Applications*, 50 (2015) 148-158.587. [CrossRef]
5. S. Kalita, B. Sharma, and U. Sharma, ``Attacks and countermeasures in mobile ad hoc network - An analysis",*Int. J. Adv. Comput. Theory Eng.*, vol. 4, no. 3, pp. 16-21, 2015.
6. H. L. Nguyen and U. T. Nguyen, "A study of different types of attacks on multicast in mobile ad hoc networks",*Ad Hoc Netw.*, vol. 6, no. 1, pp. 32-46, 2008. [CrossRef]
7. C. Panos, C. Ntantogian, S. Malliaros, and C. Xenakis, ``Analyzing, quantifying,and detecting the blackhole attack in infrastructure-less networks,"*Comput. Netw.*, vol. 113, pp. 94-110, Feb. 2017. [CrossRef]
8. N. Khanna and M. Sachdeva, ``A comprehensive taxonomy of schemes todetect and mitigate blackhole attack and its variants in MANETs," *Comput.Sci. Rev.*, vol. 32, pp. 24_44, May 2019. [CrossRef]
9. S. Sharma, Rajshree, R. P. Pandey, V. Shukla, "Bluff-Probe Based Black Hole Node Detection and Prevention", *IEEE International Advance Computing Conference (IACC 2009)*, pp. 458-462, March, 2009. [CrossRef]
10. C. Jiwen, Y. Ping, C. Jialin, W. Zhiyang, L. Ning, "An Adaptive Approach to Detecting Black and Gray Hole Attacks in Ad Hoc Network",*24th IEEE International Conference on Advance Information Networking and Application (AINA 2010)*, pp. 775-780, April,2010.
11. Y. F. Alem, Z. C. Xuan, "Preventing Black Hole Attack in Mobile Ad-hoc Networks Using Anomaly Detection",*2nd International Conference on Future Computer and Communication (ICFCC 2010)*, Vol. 3, pp. 672-676, May, 2010.
12. Dr. S. Tamilarasan, "Securing and Preventing AODV Routing Protocol from Black Hole Attack using Counter Algorithm*", International Journal of Engineering Research & Technology (IJERT)* Vol. 1 Issue 5, July - 2012 ISSN: 2278-018.
13. Haas, Z. J., 1997 (ps). A new routing protocol for the reconfigurable wireless networks. Retrieved 2011-05-06.
14. A. Tripathi and A. K. Mohapatra, "Mitigation of Blackhole attack in MANET," *2016 8th International Conference on Computational Intelligence and Communication Networks (CICN)*, pp. 437-441, 2016. [CrossRef]
15. T. N. D. Pham and C. K. Yeo, "Detecting Colluding Blackhole and Greyhole Attacks in Delay Tolerant Networks," in *IEEE Transactions on Mobile Computing*, vol. 15, no. 5, pp. 1116-1129, 1 May 2016. [CrossRef]
16. A. M. El-Semary and H. Diab, "BP-AODV: Blackhole Protected AODV Routing Protocol for MANETs Based on Chaotic Map," in *IEEE Access*, vol. 7, pp. 95197-95211, 2019. [CrossRef]
17. S. Shrestha, R. Baidya, B. Giri and A. Thapa, "Securing Blackhole Attacks in MANETs using Modified Sequence Number in AODV Routing Protocol," *2020 8th International Electrical Engineering Congress (iEECON)*, 2020, pp. 1-4. [CrossRef]
18. E. Elmahdi, S. Yoo and K. Sharshembiev, "Securing data forwarding against blackhole attacks in mobile ad hoc networks", *2018 IEEE 8th Annual Computing and Communication Workshop and Conference (CCWC)*, 2018, pp. 463-467. [CrossRef]
19. N. G. Wakode, "Defending blackhole attack by using acknowledge based approach in MANETs," *2017 International Conference on IoT and Application (ICIOT)*, 2017, pp. 1-6. [CrossRef]
20. S. Pandey and V. Singh, "Blackhole Attack Detection Using Machine Learning Approach on MANET," *2020 International Conference on Electronics and Sustainable Communication Systems (ICESC)*, 2020, pp. 797-802. [CrossRef]
21. G. Li, Z. Yan and Y. Fu, "A Study and Simulation Research of Blackhole Attack on Mobile AdHoc Network," *2018 IEEE Conference on Communications and Network Security (CNS)*, 2018, pp. 1-6.
22. V. Sharma, Renu and T. Shree, "An adaptive approach for Detecting Blackhole using TCP Analysis in MANETs," *2nd International Conference on Data, Engineering and Applications (IDEA)*, 2020, pp. 1-5. [CrossRef]
23. S. Kaushik, K. Tripathi, R. Gupta and P. Mahajan, "Performance Analysis of AODV and SAODV Routing Protocol using SVM against Black Hole Attack," *2022 2nd International Conference on Innovative Practices in Technology and Management (ICIPTM)*, 2022, pp. 455-459. [CrossRef]
24. S. Barai and P. Bhaumik, "Detection and Mitigation of Blackhole Attack Effect in Opportunistic Networks," *2021 19th OITS International Conference on Information Technology (OCIT)*, 2021, pp. 155-160. [CrossRef]
25. T. Terai, M. Yoshida, A. G. Ramonet and T. Noguchi, "Blackhole Attack Cooperative Prevention Method in MANETs," *2020 Eighth International Symposium on Computing and Networking Workshops (CANDARW)*, 2020, pp. 60-66. [CrossRef]
26. M. B. M. Kamel, I. Alameri and A. N. Onaizah, "STAODV: A secure and trust based approach to mitigate blackhole attack on AODV based MANET," *2017 IEEE 2nd Advanced Information Technology, Electronic and Automation Control Conference (IAEAC)*, 2017, pp. 1278-1282.
27. I. Kaushik, N. Sharma and N. Singh, "Intrusion Detection and Security System for Blackhole Attack," *2019 2nd International Conference on Signal Processing and Communication (ICSPC)*, 2019, pp. 320-324. [CrossRef]
28. F. Taranum, A. Sarvat, N. Ali and S. Siddiqui, "Detection and Prevention of Blackhole node," *2020 4th International Conference on Electronics, Materials Engineering & Nano-Technology (IEMENTech)*, 2020, pp. 1-7. [CrossRef]

AUTHORS PROFILE

M V D S Krishna Murty Completed B.E. in CSE from University of Madaras, Chennai and M. Tech in CS from JNTU, Hyderabad. Currently, he is a research scholar in the department of CSE at JNTUH, Hyderabad. His area of interests are MANETs and Machine Learning. He has 21 years of teaching experience and 5.5 years of industrial experience as a software professional. He has presented technical papers in the area of MANETs and Data Science at international conferences held in India. Also, he has publications in reputed international journals.

Dr. Lakshmi Rajamani, obtained Ph.D (CSE) from Jadavpur University, Kolkata and worked as a Professor and Head in the department of CSE at OUCE, Osmania University, Hyderabad. Her area of interests are Fuzzy Logic and Network Security. She has several papers published in reputed international journals. Also, she has presented technical papers in international conferences held in India and abroad.