A SURVEY ON SECURING MANETS FROM MALICIOUS BEHAVIOR BY DETECTION MECHANISM

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Abstract--There is a migration from wired network to wireless network in last few years due to the property of mobility and scalability. Mobile Ad hoc network is an infrastructure less network. Each node in Mobile Ad hoc Network acts as both the sender and the receiver. Nodes can communicate with each other by single hop, when they are in same communication range. Otherwise, it uses the multi hop to communicate by using the coordination of intermediate node to transmit the data. Unfortunately, it is vulnerable to various kinds of attack, because of open medium and wide distribution of mobile nodes. According to the properties of Mobile Ad hoc Network, it is not enough with only using the prevention mechanism. So, there is a need for detecting misbehaving node in order to secure Mobile Ad hoc Network. Aim of this paper is to classify the types of misbehavior and technique used for detecting this misbehaving node in the Mobile Ad hoc Network. Using these kinds of technique, it is easy to overcome the problems in Mobile Ad hoc Network and increase the security in Mobile Ad hoc Network.

Keywords--MANET (Mobile Ad hoc Network)., Intrusion detection system, DSR (Dynamic source routing protocol), EAACK (Enhanced Adaptive Acknowledgement), WATCHDOG, Cooperation.

I. INTRODUCTION

In MANET, a collection of nodes that are interacting with each other to implement the routing in order to enable the communication by using dynamic paths. These collections of mobile nodes have both connectionless data transmitter and the receiver. To calculate the dynamic path, they will use multiple routing protocols, they are Dynamic Source Routing (DSR) is proposed by D. Johnson et al [1], Ad Hoc On-Demand Distance Vector (AODV) is proposed by C.E Perkins et al [2], and Destination-Sequenced Distance-Vector (DSDV) is proposed by C.E Perkins et al [3].

One of the advantages of MANET is to allow data communication between the different parties, which are still maintaining the mobility. Each node has a limited transmission range. The mobile nodes can't communicate directly, when the mobile nodes are beyond the transmission range. So they use the intermediate parties to relay the data packet. For this, MANET uses single hop and multi hop communication. When the mobile nodes are in same communication range they use single hop technique, otherwise it uses multi hop technique. Because of some unique properties called minimal configuration and quick deployment of MANET, it is easily used in many applications. These applications are natural or human induced disaster, military applications and medical emergency as shown in Figure 1.

The MANET has several characteristics they are dynamic topologies, bandwidth constrained and energy constrained is proposed by Sonia Boora et al [4]. The goals of MANET are

- *Confidentiality:* Protection of data from the unauthorized access. In MANET this is more difficult to achieve. Because intermediate node receive the packets from other sender. So they can easily eaves drop the information being routed.
- *Integrity:* Message being transmitted is never altered.

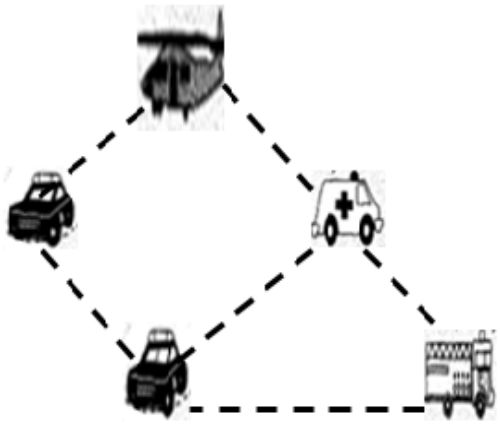

Figure- 1 Example of MANET

- *Availability:* Data should be available whenever required. On physical and access control layer attacker can use jamming technique to interface with communication on physical channel. On the network layer the attacker can disturb the routing protocol.
- *Authentication:* Assurance that an activity of concern or the origin of a communication is what an attacker would impersonate a node, thus gaining unauthorized access to resource and sensitive information and interfering with operation of other nodes.
- *Non Repudiation*: It ensures that sender and receiver of a message can't deny that they have ever sent or received such a message. This is helpful when we need to discriminate if a node with some undesired function is compromised or not.
- *Anonymity:* Anonymity means all information that can be used to identify owner or current user of node should default be kept private and not be distributed by node itself or the system software.
- *Authorization:* This property assigns different access rights to different types to different types of users. For example a network management can be performed by network administrator only.

In Addition to this, truth worthiness, privacy, correctness, reliability and fault tolerance also consider is proposed by Mavur. C. Patel [19].

MANET consists of multiple broadcast natures based on number of destination nodes. They are unicasting sending message from a source to single destination, multicasting sending a message from a source to multiple destinations, broadcasting flooding of messages from a source to all the other nodes in the specified network, geocasting send a message from source to all the nodes inside the geographical region.

The most kind of protocol used in MANET is for routing, they just assume that the mobile nodes are not cooperate to transmit the data packet are malicious node is proposed by L. Buttyan et al [5]. But the attacker can easily insert the non-cooperative nodes into the MANET. In MANET, the mobile nodes are widely distributed. So the centralized monitoring method is not efficient for this kind of wireless network. Thus there is a need to develop the intrusion detection system.

II. MANET FEATURES AND THEIR SECURITY

The following features of MANET make more vulnerable than wired networks.

- *Infrastructure less:* Central servers, dedicated hardware, and static routers are necessarily absent. The lack of such infrastructure precludes the distribution of centralized host interactions.
- *Multi-hop*: Hosts are themselves routers. Thus, packets follow multihop routes and pass through different mobile nodes before arriving at their final destination. Due to the possible untrustworthiness of such nodes, this feature presents a serious vulnerability.
- *Node movement autonomy:* Mobile nodes are normally self-directed units that are capable of drifting independently.
- *Wireless link use*: Wireless link usage condenses ad hoc networks susceptible to attacks. Attacks on a wireless ad hoc network can come from all directions and target any node. Hence, ad hoc networks will not have a clear line of defense, and every node must be prepared to defend against threats.
- *Unstructured:* Node mobility and wireless connectivity allow nodes to enter and leave the network spontaneously, to form and break links unintentionally. Therefore, the network topology has no fixed form regarding both its size and shape, i.e., it changes frequently. Any security solution must take this feature into account.

- *Power limitation:* Ad hoc enabled mobile hosts are small and lightweight, and they are often supplied with limited power resources, such as small batteries. This limitation causes vulnerability, namely, attackers may target some nodes' batteries to disconnect them, which may lead to a network partition. This is called an energy starvation attack or sleep deprivation torture attack. This feature also represents a challenging constraint when designing security solutions for MANETs.
- *Memory and computation power limitation:* Ad hoc enabled mobile nodes have limited storage devices and weak computational capabilities. Consequently, high complexity security solutions, such as symmetric or asymmetric data encryption, are difficult to implement.
- *Mobile devices physical vulnerability:* Mobile devices used in MANETs, and in mobile networks in general, are lightweight and portable. This represents vulnerability, since the devices and the information stored in the devices can be easily stolen. Mechanisms for protecting both devices and information should be employed.

III. ROUTING IN MANET

Routing protocol for MANET can be classified into several types. The classification tree is shown below. The classification is not mutually exclusive and some protocols fall in more than one class. The routing protocol for MANET can be broadly classified into four categories is proposed by Praveen kumar. B[20].

Routing information update mechanism: This mechanism can be classified into three types. They are proactive routing protocol, reactive routing protocol, Hybrid routing protocol. In proactive routing protocol every node maintains the network topology information. The reactive routing protocol each node calculate path to destination when it required sending packet. The hybrid routing protocol combines the property of both proactive and reactive routing protocol.

Use of temporal information for routing: This classification of routing is based on the use of temporal information used for routing. Since MANET are highly dynamic and path breaks are much more frequent than in wired networks, the use of temporal information regarding the lifetime of the MANET and the life time of paths selected assumes significance. This can be classified in to routing protocols using past temporal information and routing protocols that use future temporal information. Routing protocols using past temporal information uses past information about links to find routing path from source to destination. Routing protocols belonging to this category information about the expected future status of the wireless links to make appropriate routing decisions.

Routing topology: In MANET, due to their relatively small number of nodes, can make use of either a flat topology or a hierarchal topology for routing. Flat topology routing protocols make use of a flat addressing scheme which is used in IEEE 802.3. Hierarchal topologies make use of a logical hierarchy in the network and an associated addressing scheme.

Utilization of specific resources: This consists of two categories like power-aware routing and geographical information assisted routing. Power aware routing protocols wishes at diminishing the consumption of very key resources in MANET is battery life. Geographical data aided routing progress the performance of routing and cut the control overhead by effectually exploiting the geographical information available.

These are the major types of routing protocols in MANET.

IV. ISSUES IN SECURITY PROVISIONING

There are many issues in security provisioning to MANET. They are shown below.

A. Shared Broadcast Radio Channel

A separated dedicated transmission channel is used by wired network. But in MANET the radio channel is used for communication. MANET is broadcast in nature and radio channel is shared by all nodes in network. Data packet transmitted by any node is received by all other nodes which are in same transmission range. So a malicious node can easily hack the data being transmitted in the network.

B. Insecure Operational Environment

The operating environment used in MANET may or may not be always security. One of the major applications of MANET is battlefield. In this application due to the movement of mobile nodes it may or may not move in to insecure enemy territory. It is highly vulnerable to security attack is proposed by Priyanka Goyal [16].

C. Lack Of Association

MANET is a network, which is dynamic in nature. A node can join and leave from network at any time. So there is need of proper authentication mechanism is used for each node in the network. An intruder would be able to join into the network easily. They carry out attacks in MANET.

D. Lack Of Central Control

In wired networks, there is centralized controller. The centralized controller would monitor the traffic on the network by certain central point and implement security mechanism at such points. But it is not possible in MANET. Because MANET is a infrastructure less network.

E. Limited Resource Availability

Compared with wired network, bandwidth, battery power, computational power are in MANET.

F. Vulnerability

Nodes in MANET are usually compact and hand held in nature. They could get damaged easily and are vulnerable to theft.

V. ATTACKS IN MANET

Securing MANET is a big issue. Initially understanding possible kinds of attacks provide a way for increasing the security. Security of communication in MANET is important for secure transmission of information. Absence of any central co-ordination mechanism makes MANET more vulnerable to attack than wired network. These kinds of attack can be classified into two types. They are active and passive attacks are proposed by Reena Sahoo [18].

A. Passive Attacks

Passive attack is monitoring the data and a path which is regularly used to transmit the data packet without altering the content of data packet. Passive attack won't disturb the data transmission is proposed by Abhay kumar Rai et al [6], Dr. Duraiswamy et al [7]. The examples of passive attacks are eavesdropping, traffic analysis and monitoring. It is very difficult to detect the passive attack. So the best way is preventing the MANET by using effective encryption and decryption technique to encrypt and decrypt the data being transmitted. Attacks related to passive attack is explained below.

Snooping: A Snooping attack is a situation in which one person or a program successfully masquerade another data and they gaining illegitimate advantage. By using the snooping technique, the attackers can monitor the key. At the same time, using the snooping technique the server can monitor the network traffic and analyze the effective usage of bandwidth.

B. Active Attacks

This kind of attack can modify or destroy the data, which is transmitted over the network. This attack will disturb the normal operation of network. The active attack can be classified into insider or internal attacks and outsider or external attacks.

External attacks: External attacks can be created by the mobile nodes that are not belonging to the particular network region. This attack can be prevented. To prevent these attacks use standard encryption techniques and the security firewalls.

Internal Attacks: Internal attacks are caused by the misbehaving node, which are the member of domain network. These misbehaving nodes create more severe problem. It is very difficult to detect the misbehaving nodes. Because these nodes are authorized nodes of MANET.

The active attacks are created in the network layer, transport layer, application layer is proposed by Abhay kumar Rai et al [6], Dr. Duraiswamy et al [7].

Wormhole attack: Due to the broadcast nature of radio channel in MANET, the attacker can create wormhole attack. In this attack, the attacker can receives the packets at one location in the network and tunnels them to another location in the network, where the packets are resent into the network. This tunnel between the attackers is known as a wormhole attack.

Byzantine attack: A compromised intermediate node or a set of compromised intermediate nodes works in agreement and create attacks. The attacks are creating routing loop, routing path on non-optimal paths, and selectively dropping packets. This kind of attack is failure to detect. Because this network is look like a normal one. But it actually takes place byzantine attack.

Resource consumption attack: In this attack malicious node tries to consume away resources of other nodes present in the network. The resources that are targeted are battery power, bandwidth, and computational power, which are only limitedly available in MANET. The attacks could form an unnecessary request for routes, very frequent generation of stale packets to nodes. Using up the battery power of another node by keeping that node always busy by continuously pumping packets to that node is known as a sleep deprivation attack

Manipulation of data: This is the next kind of active attack. The malicious node which present in between the sender and the receiver node will receive the data from a forwarder node. It modifies the content of packet and forwards the data packet to next node. This kind of attack can be prevented by using secure message authentication method.

Grey hole attack: In the grey hole attack, an attacker node will broadcast that it has a very shortest path to any node from the entire mobile node in the network. So it will affect the concrete path to destination node is proposed by Puneet Kansal [17].

Eclipse attack: The malicious node present in the network can perform network partitioning. The attacker nodes monitor and control the data flow between the partitioned networks. This is called as eclipse attack. This is represented in the figure 2.

Session hijacking: An adversary takes control over a session between two nodes. Since most authentication process are carried out only at the start of a session, once the session between two nodes gets established, the adversary node masquerades as one of the end nodes of the session and hijacks the session.

Jamming: Jamming is the particular class of DoS attacks. The objective of a jammer is to interfere with legitimate wireless communications. A jammer can achieve this goal by either preventing a real traffic source from sending out a packet, or by preventing the reception of legitimate packets

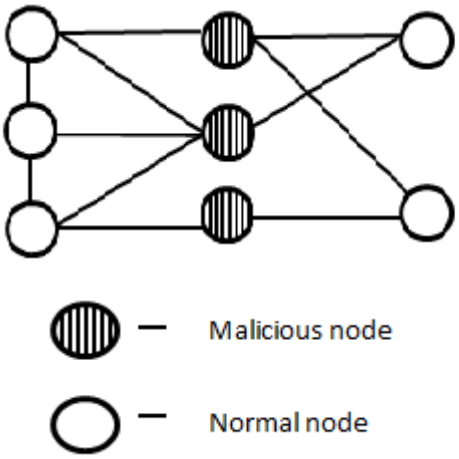

Figure-2 in Eclipse attack malicious node partitions the network.

Routing attack: There is several type of routing attack fixed on the routing protocol. They are Routing table overflow, Routing table poisoning, packet replication, route cache poisoning, rushing attack.

VI. REGULAR AND CRUEL BEHAVIOUR NODE

This section gives difference between the regular node and the misbehaving node. The definition and the character of these kinds of nodes are given below.

A. Regular Node

The main idea of security in network is maintaining the confidentiality, availability, authenticity, non-repudiation. These are the security principle of network. If a node in the network maintains this security policy, then that node is known as a regular node is proposed by Manju Khari [10].

B. Malicious Behavior

Any node in the MANET that doesn't follow this any of the security principles, then the node will be under attack. That node is known as malicious node. The types of some malicious behavior of the node are packet drop, battery drained, delay of packet, stale packets, link break, message tampering, bandwidth consumption, stealing information, buffer overflow.

VII. MISBEHAVING MODEL

Routing protocols in MANET have two basic operations. They are route finding function and data forwarding function. Routing function performs routes discovery and routes maintenance. Data forwarding functionality is used to forward data packets towards the destination over the established route b routing function. Routing protocol in MANET require a reliable environment to forward data packets. In such a situation network will become vulnerable by launching misbehaving nodes in the network. Both the routing and forwarding functionality affected with the presence of misbehaving nodes [8] proposed by Taras Fahad. The node misbehavior can be classified into following

Malfunctioning: These nodes suffer from hardware failure and software.

Malicious: This kind of nodes use their own resources and its aim to weaken other nodes or whole network by trying to participate in all established routes thereby forcing other nodes to use a malicious route which is under their control. After being selected in the requested route, they cause serious attack in form of packet dropping.

Selfish nodes: This node aim to catch profit from the networks while trying to preserve its individual resources. For example saving its battery life or bandwidth. Selfish nodes attempt to maintain communication with the nodes it wants to send data packets. But may refuse to cooperate, when it receives routing or data packets that it has no interest. So it may be drop the packet or refuse to retransmit routing packets that it has no interest [9] proposed by Meenu Chawla.

VIII. INTRUSION DETECTION SYSTEM IN MANET

Intrusion detection system in MANET is more complex than the normal wireless network. Because in MANET it is difficult to collect the required data from the mobile node to detect the intrusion in network.

There are many challenges to develops the ID'S in MANET. There is no centralized point, which is used to collect data about the network. Due to the dynamic change of topology attacker can easily make intrusions. Mobile nodes have limited power, computing capability and memory. There is no fixed topology in MANET make the intrusion process is more complicated.

A mobile node in MANET assumes that all the other nodes in the network are cooperating with each other to forward the data packet from source to destination. But these assumption leads to make an opportunities by including one or two compromised nodes in the network. So the prevention mechanisms are not enough for MANET. To overcome these attacks, there is a need to develop IDS to increase the security level of MANET. IDS usually act as a part of MANET. This section mainly describes about the different kinds of approach to detect intrusion.

A. Watchdog And Pathrater

The source node S wants to forward a packet to destination D. Intermediate node A, B, C are used to relay a packet to destination D. Node A can't transmit data packet to node C directly. So it forwards data packet to node B, and node A can confirm the packet forwarded to node C by node B through overhearing the transmission from node B to node C which is shown in Figure 3.

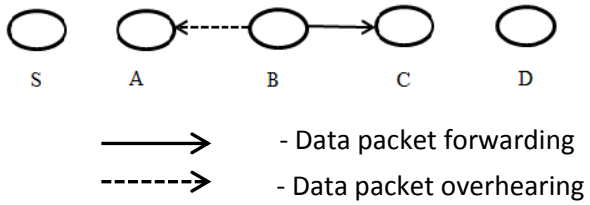

Figure- 3 Working of watchdog

All nodes in MANET maintain a local buffer, these buffer store the recently forwarded packet and compare this packet with the overheard packet. If both the packets are same, then node A will confirm that the node B successfully forwards the packet to node C.

It can't detect the misbehaving nodes in the presence of ambiguous collision, receiver collision, limited transmission power, false misbehavior, collusion and partial dropping is proposed by S. Marti et al [11].

In path rater, nodes in MANET will gather and maintain the information about malicious nodes with link reliability, to use this link during the data transmission. It calculate the multiple path to single destination from the source node and maintain the path in route cache, which is the concept used in DSR is proposed by D. Johnson et al [1]. From the multiple paths, source node selects the significant path which is lower in length or less number of hops. The pathrater uses this kind of information which is gathered from watchdog.

B. ExWatchdog

Its name implies, ExWatchdog is proposed by S. Marti et al [11] is an extension of watchdog and their function is to detect the malicious nodes and report the information to pathrater. The ExWatchdog can overcome problems in watchdog described in section A. Aim of ExWatchdog is to detect a node which falsely reports that the other nodes as a misbehaving node. This node can partition the network. These nodes are known as selfish node, which cause the major problem. In this system they use strong encryption mechanism and lengthy keys to make the system secure. Main function is to detect the malicious node and report this information to response system.

C. TWOACK

TWOACK is proposed by N. Nasser et al [12] is a technique for routing in order to detect the routing misbehavior mobile nodes. TWOACK scheme to diminish the influence of misbehaving node. The concept of this TWOACK is to send a two-hop acknowledgement to source node in the reverse direction but in same path. The TWOACK work is based on a dynamic source routing (DSR) is proposed by D. Johnson et al [1].

The working process is shown in figure 3. Node A forwards a packet to node B, node B forward the same packet to node C. Node C is two hops away from node A. Now node C send TWOACK packet to node A. Then the node A will confirm the packet is transmitting to C by node B successfully.

The TWOACK solve problems like receiver collision and limited transmission power, which is created in watchdog, is proposed by S. N. Chobe [15]. But problem associated with the TWOACK is due to frequent transmission of TWOACK, it reduces battery power of nodes. So, it can decrease the life time of nodes in MANET. So it spoils the entire network.

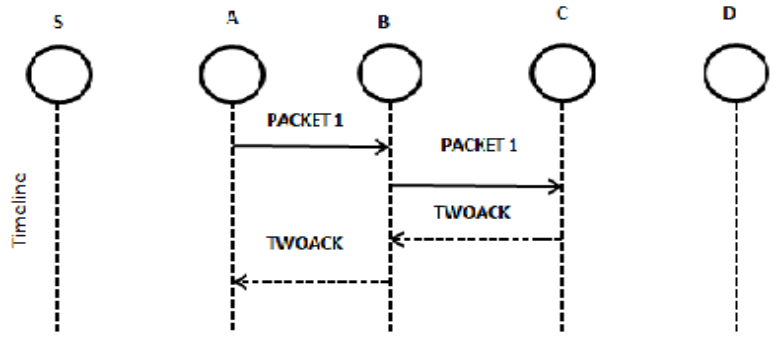

Figure-3 TWOACK scheme

TWOACK is an acknowledgement-based scheme, to detect intrusion in MANET. By considering the security, there is a need to guarantee that the acknowledgement packets are valid and authenticated. By developing an ACK scheme with digital signature technique this problem can be easily solved. This is known as Enhanced Adaptive ACKnowledgement (EAACK).

D. EAACK

This section provides description about the EAACK is proposed by Kejun Liu et al [13] approach. The major part of the EAACK is ACK, S-ACK and Misbehavior Report Authentication (MRA). To distinguish the different acknowledgement packet, they include flag bit in header of packet.

ACK: The ACK is proposed by Elhadi M. Shakshuki et al [14] is a part of EAACK. ACK is an end-to-end acknowledgement approach. The main purpose of using ACK is to reduce network overhead. This acknowledgement is used, when there is no detection of malicious node in network. The end-to-end acknowledgement scheme is described in figure 4.

The source node S sends an ACK data packet P_{ad1} to destination node D. The intermediate nodes relay ACK data packet P_{ad1} to destination. After receiving ACK data packet P_{ad1} by destination node D, then node D send back an ACK acknowledgement packet P_{ak1} to the source. The source must receive ACK acknowledgement packet P_{ak1} via same path but in reverse order within the particular period of time. The timeline in the source node S maintains the time. If above two conditions are satisfied, then the packet transmission from source node S to destination node D is successful. Otherwise, node S shifts to next technique S-ACK to detect intrusion.

Secure ACK: Secure ACK is proposed by Elhadi M. Shakshuki et al [14] is more effective than TWOACK is proposed by N. Nasser et al [12]. The target of Secure ACK is to find misbehaving node with the existence of receiver collision and limited transmission power is proposed by S. Marti et al [11]. The norm of secure ACK is, every three successive nodes has to work together to found the malicious node in network. For every three successive node in the route, the third node needs to send a secure ACK packet P_{sak1} to first node after receiving data packet $P_{sad1.}$

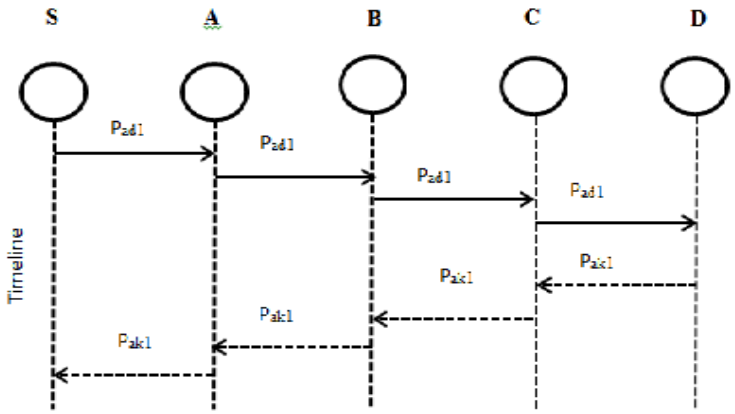

Figure-4 ACK scheme

The figure 5 shows that the nodes A, B, C are the three successive nodes. Node C wants to send back a secure acknowledgement packet to node B within a predefined time. If node A doesn't receive the secure acknowledgement packet in predefined time, the node A reports that nodes B and C are malicious to source node A.

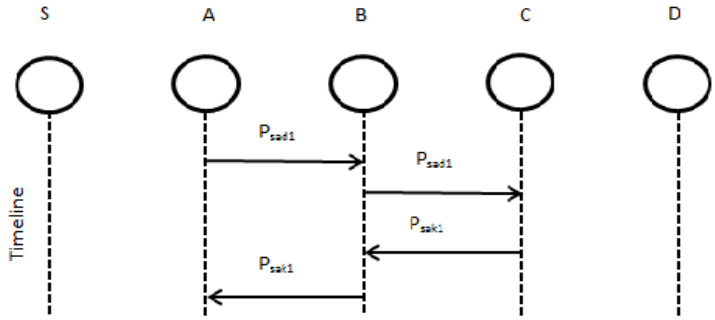

Figure- 5 S-ACK scheme

Unlike TWOACK is proposed by N. Nasser et al [12], Secure ACK of source node S doesn't confirm that node B, C are cruel node. So the node S is move to Misbehavior Report Authentication (MRA).

Misbehavior Report Authentication (MRA): MRA is proposed by Elhadi M. Shakshuki et al [14] scheme is to overcome the existence of false misbehavior report. The false misbehavior report is generated by attacker node which incorrectly report that the blameless node as a malicious node. This kind of attack leads to network partition. The principle of MRA structure is to check whether the destination node D has received the packet through different path, which is already conveyed that the packet doesn't reached the destination node D.

MRA mode is commenced by source node, it search the alternative path in its local database. If any path is available, then the source node uses this alternative path to reach the same destination node D. If there is no path to destination node D in the local database of the source node S, then the source node S uses the dynamic source routing protocol proposed by D. Johnson et al [1] to find alternative path.

After finding the alternative path, source node S will send a same packet to destination node D via alternative path. This data packet is known as MRA packet. When this destination node D receives an MRA packet, node D compare this MRA packet with the data packet stored in local database and it will send an MRA acknowledgement to source node S. If the data packet is already received, then the source node S can conclude that the report is a false misbehavior report and the node which generates in this report is a malicious node. Else, this misbehavior report is reliable and believed.

IX. CONCLUSION

Mobile Ad hoc networks, it is an active research area over past few years. Because it is applicable in military and battle field area. Mobile Ad hoc networks are open to different types of attack. This misbehaving node cause severe affect to the network. Where all nodes are cooperating with each to detect the malicious node. Even though highly effective detection mechanisms have been proposed, intruders often use new methods to attack the networks. Due to that, devising new techniques for intrusion detection based on the newly emerging attacks is a very important area of research. The detection mechanisms also have to be protected. Even sometimes the network may get failure. Thus this is a never ending research area.

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