Survey on Secure Routing Protocols in MANET

Dr. V.Umadevi Chezhian[1] S.Geetha[2], G.Geetharamani[3]

Department of CSE, Shanmuganathan Engineering College, India[1]

Department of MCA, Dept of Mathematics, BIT Campus Tiruchirappalli, India [2]

Dept of Mathematics, BIT Campus Tiruchirappalli, India [3]

Abstract: MANET is a self-configuring network thus the network's wireless topology may change rapidly and unpredictably. Surveys of various existing secure routing protocols have been proposed in MANET's and discussed about the various security analysis. The secured adhoc networks have to meet main security attributes are availability, confidentiality, authentication and integrity. This paper have been analysed and detailed survey on the secure routing protocols namely SDSDV, SEAR, Ariadne, Endaira, SOLSR, SAODV and ARAN and also explained the secure versions of the protocols are discussed. The various attacks and security mechanisms of the above mentioned protocols has been discussed and the comparative study of advantages and as well as disadvantages of each protocols has been mentioned.

Keyword: SDSDV, SEAR, Ariadne, Endaira, SOLSR, SAODV and ARAN

I.INTRODUCTION

Mobile ad hoc network devices such as laptops, PCs, cellular phones, appliances with ad hoc communication capability link together create a network. Current technology is the key to solving today's most common communication problems such as having a fixed infrastructure, and centralized, organized connectivity, etc. The Manet routers (mobile devices, nodes) are free to move randomly and organize themselves arbitrarily; thus, the network's wireless topology may change rapidly and unpredictably. The network appears on-demand, automatically and instantly, and data hops from ad-hoc device to device till it reaches its destination, the network updates and self reconfigures to keep nodes connected. The network topology changes when a node joins in or moves out. Packet forwarding, routing, and other network operations are carried out the by the individual nodes themselves [16].

In MANETs with each node acting as a router and dynamically changing topology the availability is not always guaranteed. It is also not guaranteed that the path between two nodes would be free of malicious nodes. The wireless links between nodes are highly susceptible to link attacks (passive eavesdropping, active interfering, etc). Stringent resource constrains in MANETs may also affect the quality of security. At the time of excessive computations is required to perform some encryption and decryption acts. The vulnerabilities and characteristic make a case to build a security solution, which provides security services like authentication, confidentiality, integrity, non-repudiation and availability. In order to achieve the goal which we need a mechanism that provides security in each layer of the protocol. [16], [17]

Protection of MANETs can be divided into two categories, such as protection of the routing functionality (secure ad hoc routing) and protection of the data in transmission (secure packet forwarding). The way of approaching the MANETs protection can also be divided into two categories, such as proactive and reactive. Proactive approach attempts to prevent an attacker from launching attacks, through cryptographic techniques. In reactive approach it seeks to detect threat and react accordingly. [16]

The main objective of this paper is to give an overview of secure routing protocols, security analysis and comparison of those secure routing protocols. The remainder of this paper is structured into six sections. Section1 generally introduces the Manet, , section2 explains the security aspects of Manets section3 discusses Security challenges, section4 discusses Threats in Manets, section5 discusses the issues in securing the routing protocols section6 discusses cryptographic Mechanism for Routing in Manets, Section7 explains security routing protocols in Manets and section8 compares Secure routing protocols.

II. SECURITY ASPECTS OF MANETS

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MANETs require the four standard security attributes[10].
1)*Availability*, which requires that the system stays up and in a working state, and provides the right access and functionality to each user. This security aspect is the target of DoS or DDoS attacks.
2)*Confidentiality,* which requires that the information will not be read or copied by unauthorized parties. authentication and other access control techniques are used to achieve this goal.
3)*Authenticity,* which requires that the communication peer is really the legitimate node and is exactly whom we expect to talk, and that the content of a message is valid.
4)*integrity,* which requires that communication data between nodes must not be modified by any unauthorized, unanticipated or unintentional parties.

III. SECURITY CHALLENGES

A central vulnerability of MANET comes from Peer-to-Peer architecture in which each node acts like a router to forward packets to other nodes. Moreover, these nodes on network share the same opened environment that gives opportunity for malicious attackers. In [11] and [12], the challenges for MANET security can be summarized as follows:

1)Lacking of central points: because of characteristics of MANET such lacking gateways, routers, etc, the mobile nodes just know some neighbours in its range. This introduces new difficulties for security designs such as facing with the change of network topology, resource constraint .
2)Mobility: MANET nodes can leave, join, and roam in the network on their own will, so the topology of network is changed frequently . Therefore, some proposed security solutions to adapted with the change of topology. However, this also raises new problems for these systems.
3)Wireless link: In wireless environment, a plenty of collision occurred when nodes send and receive the packets. The wireless channel is also subject to interferences and errors, exhibiting volatile characteristics in terms of bandwidth and delay. In addition, some services such as routing protocols, broadcast services have to communicate with others in real-time, this can flood the network traffic.
4)Limited resources: The mobile nodes like laptop, PDA are generally constraint in battery power, processing speed, storage, and memory capacity. Therefore, the operation of security solutions can be reduced the accuracy, efficiency such dropping packets, numerous time for computation.
5)Cooperativeness: MANET is a mobility network, so nodes have to communicate with others by using routing protocol such AODV, DSR…Therefore, this can make these protocols to become a target of the attacks.

IV. THREATS IN MOBILE AD HOC NETWORKS

The Protocols in MANET are vulnerable to many different types of attacks. In this section, I would like to list different types of attacks that are possible in these networks[13].

1)Attacks Using Modification An attacker node may modify certain contents of the routing packet, thus propagating incorrect information in the network
2)Attacks Using Impersonation A malicious node may try to impersonate a node and send data on its behalf. This attack is generally used in combination with modification attack.
3)Attacks Using Fabrication An attacker may try to fabricate a false Route Error message, which may cause other nodes to remove a particular node from it routing table.
4)Black Hole An attacker may create a routing black hole, in which all packets are dropped. by sending forged routing packets, the attacker could route all packets for some destination to itself and then discard them.
5)Gray Hole As a special case of a black hole, an attacker could create a gray hole, in which it selectively drops some packets but not others, for example, forwarding routing packets but not data packets
6)Replay In replay attack, previously captured routing traffic is sent back into the network to target new routes.
7)Wormhole This attack requires two malicious nodes where one node captures routing traffic, and sends it to the other malicious node. Then, the second node can send back selective information to the network.
8)Blackmail Here, the attacker can fabricate a list to block nodes and inject it into the network. This attack targets routing protocols that block malicious nodes by sending a black list of offenders to legitimate nodes.
9)Denial of Service This attack has two types: a) Routing table overflow, and b) Sleep deprivation torture. In the first type, the attacker floods the network with bogus route creation packets in order to prevent the correct creation of routing information, and to consume resources of nodes. In Sleep deprivation torture, the attacker sends diverse routing information to a specific node in order to make it consume its batteries because of the constant routing processing.

V. ISSUE IN SECURING THE ROUTING PROTOCOLS

Securing the routing protocols for ad hoc networks is a very challenging task due to its unique characteristics [14]. A brief discussion on how the characteristics causes' difficulty in providing security in ad hoc wireless network is given below.

1)***Shared radio channel:*** Unlike the wired networks where a separate dedicated transmission line can be provided between a pair of end users, the radio channel used for communication in ad hoc networks is broadcast in nature and shared by all nodes in the network. Data transmitted by a node is received by all the nodes within its direct
2)Transmission range. malicious node can easily obtain data being transmitted in the network. Insecure environment: The environment in which MANET are generally used may not be always secure, for example, The defense battle field. In such environment, nodes may move in and out of hostile and insecure enemy territory, where they would be highly vulnerable to security attacks.
3)Lack of central authority: infrastructure based wireless networks it would be possible to monitor the network traffic through routers or base stations and implement security mechanisms at those points. Since MANET don't have any such central points, these mechanisms can't be applicable to them.
4)Lack of association rules: In MANET, since nodes can leave or join the network at any point of time, if no proper authentication mechanism is used for associating nodes with the network intruders can easily join the network and carry out attacks.
5)Limited availability of resources: Resources such as bandwidth, battery power and computational power are scare in ad hoc networks. Hence, it is difficult to

implement complex cryptography-based security mechanisms in such networks.

VI. CRYPTOGRAHIC MECHANISM FOR ROUTING IN MOBILEAD HOC NETWORKS

Cryptographic mechanism [15] is the most common and reliable means to ensure security and is not specific to *ad hoc* wireless networks, but can be applied to any communication network. This is some of the main mechanism used in MANETs :

1)Asymmetric cryptography : It is also known as public-key cryptography. In public key cryptography, there is a pair of public/private keys. The private key is kept private, while the public key can be public to others. One of the earliest public-key cryptographic techniques, known as RSA. Digital signature, key management, and other techniques have been developed in public-key cryptography, such as the ElGamal cryptograph system, DSA, and elliptic curve cryptography.

2)Symmetric cryptography*:*The encryption key is closely related to the decryption key in that they are identical in most cases. In practice, keys represent a shared secret between two or more parties that can be used to maintain private communication. Usually the network can choose a shared secret key to encrypt and decrypt the message once two more parties use a public/private key pair to build trust in the handshake stages, which is more feasible and efficient from a computational standpoint than asymmetric key techniques.

3)HMAC message authentication code: It is a type of message authentication code calculated using a hash function in combination with a secret key. It can also be used to make sure that the message sent unencrypted retains its original content by calculating the message HMAC using a secret key.

VII SECURITY ROUTING PROTOCOLS IN MANET

i)ARAN

ARAN [1], [2] is stand for Authenticated Routing for Ad Hoc Networks. ARAN is a security scheme, which can apply to any on-demand routing protocol. ARAN is similar to SAODV in many points; both of them are based on digital signature and also both of them uses control messages. Routing operations of ARAN's are performed using three data structures: Route Discovery Packet (RDP), Reply message (REP) and error message (ERR). These messages have the same functionality of RREQ, RREP and RERR messages in SAODV. Each of these messages has secured by digital signatures. These messages use the forward path and the reverse path during the routing discovery process. The messages use certificate revocation for detecting expired public keys.

By model checking the two most common execution scenarios of ARAN with the AVISPA Tool, we have discovered the following attacks:

- *route disruption*, which occurs when the intruder prevents a route from being discovered;
- *route diversion*, which occurs when the intruder does not prevent the establishment of routes, but it achieves that some established routes are diverted;
- *creation of incorrect routing state*, which occurs when the intruder jeopardizes the routing states in some nodes.

These attacks can be implemented by relying on some *spoofing behavior* of the intruder. We have found two different kinds of spoofing attacks on ARAN. In the first case, the intruder assumes the identity of a node that has moved away from its initial position; the node remains connected to the rest of the network only because of the intruder. Due to the spoofing activity of the intruder, the node can become part of a routing path, although it is actually disconnected from the rest of the network. This malicious activity can clearly lead to a route-diversion attack as well as a creation-of-incorrect-routing-state attack, as routing tables would contain incorrect information. A different spoofing attack can be achieved by using a number of malicious nodes to immediately forward route requests towards the destination. In this manner, the intruder bypasses the nodes in the route path together with the cryptographic calculations of the protocol. This immediately leads to a route-disruption attack as well as a creation-of-incorrect-routing-state attack.

ii)SAODV

The SAODV[3] protocol provides security mechanisms based on non-invertible hash functions and public key cryptography use applied to the on-demand routing protocol AODV. The node authenticity is guaranteed through the knowledge of the public key in each node of the network. An underlying key distribution mechanism is supposed to exist in the network.

In SAODV, hash chains are applied for the hop count authentication so that each node, at every hop can verify that the hop count metric was not maliciously decreased. In order to protect the immutable field of routing messages, each node generating a message includes a digital signature generated through its private key. Two modalities for the working of the protocols can be observed are 1) Destination only reply and 2) Route cache reply.

It is important to observe how in the first mechanism is a signature and second id modality. SAODV is possible to note the asymmetry algorithm in the resource deployment during the verification and signature of RSA. SAODV uses a double signature mechanism to allow an intermediate node to reply to a route discovery request on behalf of destination in order to reduce the complexity and computational overhead of double signature. This kind of mechanism applied in SAODV would require a HELLO periodical messaging mechanism activation for neighbor updating. The applied approach avoids this issue not introducing particular computational overhead because nodes observations is local such as decisions to react to some selfish behavior.

SAODV is applied to a well know routing protocol, in order to improve its performance and to offer more resilience to attack from malicious nodes authenticated by the network. A preventive approach based on a cryptographic mechanism and a reactive approach to direct the anomalous and malicious behavior of nodes is considered.

iii)SDSDV

SDSDV[4] protocol is based on the regular DSDV protocol. Within SDSDV, each node maintains two one way hash chains about each node in the network. Two additional fields are AL field(alteration) and AC field (accumulation) are added to each entry of the update packets to carry the hash values. With proper use of the elements of the hash chains, the sequence number and the metric values on a route can be protected from being arbitrarily tampered. This security in the routing protocols is necessary in order to defend against hostile attacks. The major goal is to protect the sequence number and the metrics in each entry of an update from being arbitrarily changed. SDSDV postulates that each node in the network, including itself, with one used for guarding against the decreasing metric attack and the other for against increasing metric attack.

When listing an entry in an update for itself, a node places its own id and the hash value used for AC field relating to itself of current sequence number and metric. When an intermediate node transfers an entry for a destination node, it places in the AL field the id and the hash value in AL field received from the neighbor from which it learned the route to that destination. When an intermediate node receives an entry, it verifies the hash values in AL and AC fields. If the entire values pass the verification, the node accepts the entry otherwise the entry is neglected.

iv)ARIADNE

Secure On-Demand Routing Protocol for Ad hoc Network, ARIADNE [5], [6] is also proposed to secure DSR. Similar to SRP, it requires pre-deployment of authentication keys between the source and destination. Ariadne provide three key sharing approaches corresponding to three Authentication methods: pair wise shared secret keys, TESLA keys; shared secrets between communicating nodes combined with broadcast authentication; and digital signature. Pair wise shared secret keys authenticate DSR routing messages by using secret key between each pair of nodes. This requires n(n-1)/2 keys for a network consisting of n nodes. Pair wise shared secret keys avoid need for synchronization. TESLA requires time synchronization which is difficult to achieve in MANET environments. Each node should have a hash chain; the authentic element of each hash chain should be distributed to all network nodes. Also digital signature requires pre-deployed asymmetric cryptography for the authentication process.

Prior research in ad hoc networking has generally studied the routing problem in a non-adversarial setting, assuming a trusted environment. In this paper, we present attacks against routing in ad hoc networks, and we present the design and performance evaluation of a new secure on-demand ad hoc network routing protocol, called Ariadne. Ariadne prevents attackers or compromised nodes from tampering with uncompromised routes consisting of uncompromised nodes, and also prevents a large number of types of Denial-of-Service attacks. In addition, Ariadne is efficient, using only highly efficient symmetric cryptographic primitives. Our proposed distributed technique is based on the propagation speeds of requests and statistical profiling; they do not require network-wide synchronized clocks, do not impose any additional control packet overhead, and need only simple computations by the sources or destinations of connections.

v)ENDAIRA

EndairA[6],[7] is one of the most secure ones and provides several defense mechanisms against so many types of attacks. It also incorporates our novel tunnelling prevention mechanism into this modified version of endairA to defend it against the tunnelling attack. The mechanism utilizes the delays between receiving and sending control packets of endairA computed locality by all intermediate nodes. It detailed security analysis shown that it can limit the adversary's, ability to launch undetected tunnelling attack to an acceptable level. Our proposal does not change the number of control packets involved in endairA and only modifies the RREP messages slightly.

endairA achieves a great efficiently in bandwidth utilization and computation overhead. It prevents adversarial nodes from impersonation forging, deleting any node from the list by the RREP packets. One of the most important features of one proposed mechanism to defend endairA against tunnelling attack is that it is a cross-layer approach in which the MAC layer timing operation has been exploited in the network layer operation and signaling. The reason which makes it necessary to utilize a cross-layer approach is that more information about the channel conditions such as congestion, delay and number of transmission in the MAC layer.

One proposal need accurate time synchronization between all communicating nodes and with the help of more accurate GPS disciplined clocks, this is a simply accessible requirements. It detailed security analysis of the proposed approach show that it will drastically decrease the possibility of launching undetected tunnelling attack against endairA.

vi)SOLSR

Secure Optimized Link State Routing [9], provide the security with the help of signature scheme. And the approach provides the authentication between the two nodes. For providing the signature the approach uses the two functions. First one is for signature and the second is for verification

1. Sign (node id, key, message) a signature for a message can be verified in a node using a function:
2. Verify (originator id, key, message, signature).

To prevent malicious nodes from injecting incorrect information into the OLSR network, the originator of each control generates an additional security element called signature message and transmitted with the control message. A timestamp is associated with each signature in order to estimate message freshness. Thus, upon receiving the control message, a node can determine if the message originates from a trusted node, or if message integrity is preserved. Signatures are separate entities from OLSR control traffic: while OLSR control messages perform the purpose of acquiring and distributing topological information, signatures serve to validate information origin or integrity.

To compute a signature corresponding to a control message, the following protocol is used:
1. the node creates the control message;
2. the node retrieves the current time, and writes it in the Timestamp field;
3. the node computes the signature, and writes it in the Signature field;
4. the node puts the SIGNATURE message and the control message in the packet, in this exact order.
Then, the node sends the packet, or repeats the protocol for another control message before sending the packet.

vii)SEAR

A novel secure and energy aware (SEAR)[8] routing protocol to address these two issues concurrently through balanced energy consumption and probabilistic random walking. SEAR is designed with two configurable parameters, energy balance control (EBC) and security level. EBC is used to enforce energy balance and increase the lifetime. Security level is designed to determine the probabilistic distribution of the random walking that provides routing security. The security level can be defined by the message source on a message level, or on a system level.

SEAR algorithm consists of two methods for packet forwarding: shortest path forwarding based on the geographical information, and random forwarding, which is used to create routing unpredictability for source privacy and jamming prevention. As described in the introduction, we are interested in routing with energy balance, SEAR also has the flexibility to provide routing security and source privacy.

Tables1. Summary Report for Secure Routing Protocols

S.No	Protocol s	Attacks	Mechanisms	Advantages	Disadvantages
1.	SDSDV	Hostile attacks and Protects on the sequence numbers and metrics	Uses hash chain solution. SDSDV postulates that each node creates two hash chains in relation to each node in the network, including itself, with one used for guarding against the decreasing metric attack and the other for against increasing metric attack.	SDSDV can provide a complete protection on the routing messages. the hash chain approach uses symmetric cryptography which has lower computation complexity compared to asymmetric cryptograph.	1)The increased overhead in SDSDV may cause some degree of congestion in the network. This is the cost paid for routing security. 2)The longer routing delay may cause more packets to be dropped. 3)deterioration of SDSDV due to the overhead is not significant. 4)SDSDV may not suitable for a large adhoc network.
2.	SEAR	1)Trace back attacks 2)traffic jamming attacks 3)minimize possibility for DOS attacks	The algorithm consists of two methods for packet forwarding: shortest path forwarding based on the geographical information, and random forwarding, which is used to create routing unpredictability for source privacy and jamming prevention. .	SEAR can provide excellent balance between routing efficiency and energy consumption while preventing routing trace back attacks and malicious traffic jamming attacks.	Increased overhead since the a mixture of the random walking and the shortest path routing. .

3.	Ariadne	1)Fabrication attacks 2)Packetdropping attack 3)Selfish misbehavior 4)Black hole attack	1)Message Authentication Code 2)Digital signature	1)Ariadne is DSR based protocol that overcomes this attack. 2)The first implementation of this protocol is TESLA and another implementation is Meassage Authentication code.	1)The major issue is to make sure the data is secure and arrives safely without any attacks from the adversary. 2)One more issue is when dealing with the selfish misbehavior or packet dropping attack, most of the solutions are more focus on data packets and not directly applicable to control packets.
4.	ENDAIRA	1)DOS 2)Hackers 3)Selfish misbehavior	Cryptographic signature	Definition of routing security, to model the operation of a given routing protocol in the presence of adversary, and prove that the protocol is secure.	1)This is basically due to cryptographic primitives used by the launching of more route discoveries, more latency due to cryptography computation before sending the data packets.2)The most important issue is monitoring procedures
5.	SOLSR	1)Jamming 2) Spoofing Attacks	1)Signature (node id, key, message) A signature for a message can be verified in a node using a function: 2)Verification (originator id, key, message, and signature). To prevent malicious nodes from injecting incorrect information into the OLSR network, the originator of each control generates an additional security element called signature message and transmitted with the control message.	A timestamp is associated with each signature in order to estimate message freshness. Thus, upon receiving the control message, a node can determine if the message originates from a trusted node, or if message integrity is preserved. Signatures are separate entities from OLSR control traffic: while OLSR control messages perform the purpose of acquiring and distributing topological information, signatures serve to validate information origin or integrity	The increased security provided by the proposed solutions is at the expense of a greater message overhead, as exchanged control messages have a larger size and involve further computations done by both the originating and the receiving node.
6.	SAODV	1)resilience to attack from malicious nodes 2)Selfish attacks	1) Security mechanism based on non-invertible hash functions and public key cryptography. 2) SAODV uses a double signature mechanisms to allow an intermediate node to reply to their request.	SAODV resulted a good compromise between reactive information exchange and security mechanisms based on an on-demand authentication mechanisms and control overhead.	1)The resource consumption of each node for the cryptographic operations would become very expensive.2) an intermediate node spontaneously avoids replying on behalf of the destination. 3)Regarding security it uses signature mechanisms

7.	ARAN	1)route disruption, 2)route diversion, 3)creation of incorrect routing state 4) spoofing attacks	Digital signature	The messages use certificate revocation for detecting expired public keys.	it is actually disconnected from the rest of the network

VIII. CONCLUSION

Mobile adhoc network have been increase their vulnerability to attacks. This paper have discussed and presented various issues such as security attacks and threats can cause vulnerability in Manets. It has been analyzed security mechanisms of various existing routing protocols in Manets, which implements against various types of external attacks detect malicious behavior and provide a safer environment, with the secure routing can be successful authenticated and the malicious nodes can be identified. The summary report of the security issues, security attacks and surveyed completely secure mechanisms for Manets have been presented.

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