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Security Attacks and Challenges in Mobile Ad-hoc Networks

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Abstract*: Mobile ad hoc network is a network that has many free or autonomous nodes, and ad hoc network does not depend on any fixed infrastructure. As an example, routers in wired networks or access points in managed (infrastructure) wireless networks. Mobile ad-hoc wireless networks (MANETs) typically exhibit high variability in network topology and communication quality. When using mobile ad hoc network, it has less ability to attacks compare with wired networks. It has limited physical resources. The network topology is dynamically changing, it is the topology is in logically independent sub networks and it has less centralized administration. All the nodes in the topology, link to transfer data, but the wireless channel has to face attacks. They are active and passive attacks. Different types of active and passive attacks in MANETs. Security acts a major role in mobile ad hoc network and also it is an essential requirement in MANETS. When comparing wired networks the wireless networks need more secure because it has limited resources. There are security goals in MANETS. It will help to maintain a secure environment in ad hoc network. When considering this section there are security issues and challenges. Some of the challenges are dynamically changing topology, limitations of mobile nodes, infrastructure less etc. Finally proposed some solutions for preventing security issues. They are proactive and reactive solutions.*

Keywords*: Mobile Ad Hoc Network (MANET), Security, Attacks on MANET, Security Services, Network Topology, Infrastructure*

1. Introduction

Wireless networks consist of a number of nodes which communicate with each Other. Over a wireless channel which have Different types of networks such as sensor network, ad hoc mobile networks, Cellular networks and satellite network. Mobile ad-hoc network is introduced as a new technology of future wireless communication. Refer figure 1 for getting an idea about MANET Architecture. According to these kind of technologies it is needed not a centralized server and there is no fixed topology Special characteristics of MANET's are: open network boundary, dynamically and unpredictably changing topology, and multi-hop communications. In MANETS each node acts as a both a router and host. In ad-hoc network nodes are in mobile and communicating by creating temporary paths among themselves to forwarding data packets by using multi hop routing. This type of wireless network is called an infrastructure less network. Unlike traditional mobile wireless networks, Ad-hoc network do not rely any fixed infrastructure or centralized management. The nodes in MANETs are changed dynamically. When using these kind of networks, there are lots of advantages in different areas. Such as rescue and tactical operations, military and disaster recovery operations. In past years of wireless ad hoc networks can be traced back to the Defense Advanced Research Project Agency (DAPRPA).

Packet Radio Networks (PRNet), which evolved in the Survivable Adaptive Radio Networks (SURAD) program.

In an ad-hoc network, security becomes an essential and complicated. In this research paper focuses ad-hoc security, challenges, and solutions. Often wireless communication has less security than wired communication. Wired communication uses physical cables to transfer data between different devices. Most wired networks use Ethernet cables to transfer data between connected PCs. And wireless network refers to the radio frequency signals to share information and resources between devices. The reason for having less security for wireless networks is its support limited resources, such as bandwidth, storage space, processing capability, etc. Mobile ad hoc network faces many routing attacks because it has a dynamically changing topology. Attacks are

classified in two ways. They are active attacks and passive attacks [2] [3].

The rest of the paper covers as shown below. **Section 2** covers background and related works. It includes all the research papers which were referred. In **Section 3** covers the approach of this research paper. It includes boundary of the research area. In **Section 4** cover the overview of security in MANETs. It includes Security attacks, Security mechanism and Security services. In **Section 5** describes about the attacks in MANETs. The attacks can be divided into two parts. They are Active and Passive attacks. In **Section 6** covers the conclusion of this proposed research paper.

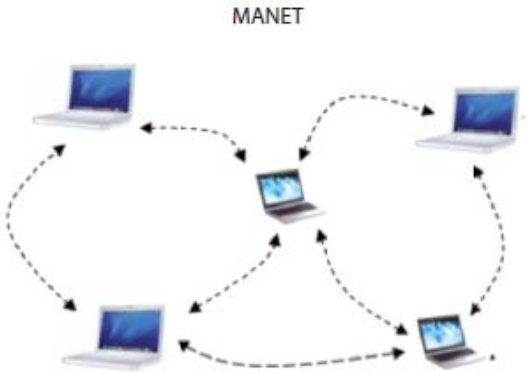

Figure 1: MANET Architecture
(Source:http://www.techbriefs.com/component/content/article/ntb/tech-briefs/information-sciences/12655)

2. Background and Related Works

The Mobile Ad hoc network is a most capable wireless technology that allows work without the need for any established infrastructure. During the last years, a large number of research projects have focused on security challenges which face under Mobile ad hoc and sensor network.

In MANET due to the random mobility of node, security becomes a complex issue. Further, it describes about the security issues which regard to transport layer for secure end-to-end communications through data encryption between two nodes, network layer for protection of routing as well as forwarding protocols, and the link layer for protection of the wireless MAC protocol and also provide link-layer security [1].

According to the attacks against the ad hoc networks may vary depending on which environment the attacks are launched, communication layer the attacks are targeting, what level of ad hoc network mechanisms is targeted. One can also see that there are several attack characteristics that must be considered in designing any security measure for the ad hoc network [2]. As a result of security it has been authenticated all the nodes by using the Digital Certificate or Digital Signature. As in Security Scheme for Mobile Ad-hoc Network with Reduced Routing Overhead research paper proposed security scheme for Mobile ad-hoc network with reduced routing overhead based on digital signature where a key is used by all offices in team member and it generates digital signature using encryption technique and verifies the digital signature after decrypting the digital signature. This research further discussed about providing of security from the private node in the network and the route validation scheme which used to find the availability and validation of route on the basis of hop count and time interval [3].

Mobile ad hoc Network has the ability to set up networks on the fly in a harsh environment where it may not possible to deploy a traditional network infrastructure. Due to mobility and open media nature, the mobile ad hoc networks are much more prone to all kinds of security risks, such as information disclosure, intrusion, or even denial of service. The security needs in the mobile ad hoc networks are much higher than those in the traditional wired networks. This security needs in the mobile ad hoc networks are much higher than those in the traditional wire networks [4].

MANET is a type of multi-hop network, infrastructure less and the most important self-organizing [13]. There is not such a clear, secure boundary in the mobile ad hoc network, which can be compared with the clear line of defense in the traditional wired network. When using and operate the media, wireless technology has less secure than wired technology. It is to occur because of wireless technology often has less resources, such as the speed of wireless network is slower than wired network and the range of a wireless network is limited and a typical wireless router will only allow individuals within 150 to 300 feet to access the network. Lack of secure boundaries makes the mobile ad hoc network susceptible to the attacks. The mobile ad hoc network suffers from all-weather attacks, which can come from any node that is in the radio range of any node in the network, at any time, and target to any other nodes in the network.

Attacks on network are divided into two categories. They are internal attack and external attack. In Internal attacks, the adversary (attacker) wants to gain the normal access to the network and participate in the network activities, either by some malicious impersonation to get the access to the network as a new node, or by directly compromising a current node and using it as a basis to conduct its

malicious behaviors. In External attacks, the attacker aims to cause congestion, propagate fake routing information or disturb nodes from providing services [2]. Security involves a set of investments that are adequately funded. In a MANET, all networking functions such as routing and packet forwarding, are performed by the nodes themselves in a self-organizing manner [14].

For these reasons, securing a mobile ad -hoc network is very challenging. The main requirements and goals in securing mobile ad hoc networks are as follows [4] [5] [9].

I. Availability: Availability means the assets are accessible to authorized parties at appropriate times. Availability applies both to data and to services. It ensures the survivability of network service, despite denial of service attack [14].

II. Confidentiality: It is considered about the privacy and it will confirm that the computer resources are accessible only for authorized parties. To maintain confidentiality of any confidential information, we need to keep them secret from all entities that do not have privileges to access them.

III. Integrity: Integrity means that assets can be modified only by authorized parties or only in authorized ways. Modification includes writing, changing status, deleting and creating. Integrity assures that a message being transferred is never corrupted.

IV. Authentication: Authentication enables a node to ensure the identity of peer node it is communicating with. Authentication is essentially assurance that participants in communication are authenticated and not impersonators. Authenticity is ensured because only the legitimate sender can produce a message that will decrypt properly with the shared key [14].

V. Non repudiation: Non repudiation ensures that the sender and receiver of a message cannot disavow 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 [14].

VI. Anonymity: Anonymity means all information that can be used to identify the owner or current user of node should default be kept private and not be distributed by the node itself or the system software.

VII. Authorization: This property assigns different access rights to different types of users. For example a network management can be performed by network administrator only.

Above details are the main requirements that need to be achieved to ensure the security of the mobile ad hoc network.

The weakness of MANETs occurs because of the open peer to peer architecture. In mobile ad hoc networks, there are no boundaries of the wireless channel; it is accessible to both network users as well as to malicious attackers. Due to this reason there is no clear line of defense in MANET networks with respect to security design perspective. The boundary becomes blurred that is used to separate inside network from the outside network. Due to all this there is no well-defined infrastructure in order to deploy single security solution over MANET [7].

The aims of Ad hoc networks and particularly MANET have in recent years not only seen widespread use in commercial and domestic application areas but have also become the focus of intensive research. Applications in MANET's range from simple wireless home and office networking to sensor networks and similarly constrained tactical network environments.

Security aspects play an important role in almost all of these application scenarios given the vulnerabilities inherent in wireless ad hoc networking from the very fact that radio communication takes place (e.g. In tactical applications) to routing, man-in-the-middle and elaborate data injection attacks [1]. There are numerous kinds of attacks in the mobile ad hoc network, almost all of which can be classified as the following two types [15].

In External attacks, in which the attacker aims to cause congestion, propagate fake routing information or disturb nodes from providing services. In Internal attacks, in which the adversary wants to gain the normal access to the network and participate in the network activities, either by some malicious impersonation to get the access to the network as a new node, or by directly compromising a current node and using it as a basis to conduct its malicious behaviors.

Current MANETs are basically vulnerable to two different types of attacks: active attacks and passive attacks. An active attack is an attack when a misbehaving node has to bear some energy costs in order to perform the threat. On the other hand, passive attacks are mainly due to lack of cooperation with the purpose of saving energy selfishly [16].

Nodes that perform active attacks with the aim of damaging other nodes by causing network outage are considered as malicious while nodes that make passive attacks with the aim of saving battery life for their own communications are considered to be selfish. We have classified the attacks as modification, impersonation, fabrication wormhole and lack of cooperation [2].

3. Approach

Mobile ad hoc and sensor network is a self-configuring network of mobile nodes. It has less fixed infrastructure and lack of centralized administration. When comparing with wired networks, wireless network has less security than wired networks. The reason for that is wireless network has limited resources. The network topology is dynamically changing, topology is in logically independent sub networks and it has less centralized administration. All the nodes in the topology, link to transfer data, but the wireless channel has to face attacks. Then it is needed to have a good security in wireless networks. When considering security, it has various paths to study. Such as, what is the ad hoc network security, what are the security issues and challenges, what are the solutions to prevent security attacks?

Security issues and challenges in mobile ad hoc network is a considerable topic when focus on wireless network. Wireless networking needs more security because of the limited resources. The following reasons also cause for less security in MANETS.

- Less infrastructure –each node in this topology acts as a both router and a host. The topology is changing dynamically. Nodes communicate with each other by using multi hop routing. In this network the nodes are portable. (E.g.:- Laptops, mobile phones)

- Limitation of physical security –wireless ad hoc network has a high risk to face physical security threats than wired networks.

- The network topology is dynamically changed - The nodes in a mobile ad hoc network can move independently. It will change frequently.

- Centralize administration is less –When detecting attacks, it is a very difficult problem because not easy to monitoring the traffic in large scale ad hoc network.

- Short range of transmission –ad hoc network has short range connectivity. This requires nodes depend on each other to perform multi hop routing method to connect over large areas.

- Lack of a clear line of defense - Mobile ad hoc network do not have a clear line of defense. It means attacks can come from all directions. In MANETS the boundary of the inside network separate from the outside is not clearly mentioned.

To prevent above issues in ad hoc network introduce some solutions. The followings are some solutions.

A new protocol, multiple access with collision avoidance protocol (MACA) is used to avoid the Hidden terminal and Exposed terminal problems. Use signaling packets to avoid collision. E.g.:

- Request to Send
- Clear to Send

RTS (Request to send): Sender requests the right to send from a receiver with a short RTS packet before it sends a data packet.

CTS (Clear to send): Receiver grants the right to send as soon as it is ready to receive.

4. Overview of Security

Provide a protected communication between nodes in a potentially hostile environment, security has become a primary concern. When comparing wireless network with wired network, wireless network has less security because of its limited physical security, power-constrained operations, and lack of centralized administration in a mobile ad hoc network. MANET not only inherits security issues faced in both wired and wireless networks, but it also introduces security attacks unique. Security is a major issue due to the vulnerabilities that are associated with it in Mobile Ad Hoc Networks (MANET). Mobile nodes in the network dynamically setup temporary paths among themselves to forwarding data packets due to the existence of temporary network without any fix infrastructure and centralize management. And security is essential things in mobile ad-hoc network. It is also true that security has long been an active research topic in MANET networks. The challenges are shared wireless medium, highly dynamic network topology, stringent resource constraints and open network architecture. Existing security solutions for wired networks do not apply to the Mobile ad hoc network domain. Due to some of the following reasons, Mobile ad hoc network faces different challenges.

It's especially liable to attacks because of active attacks and passive attacks, due to lack of Trusted Third Party adds. One approach is to consider three aspects of information security:

- **Security Attack:** Any action that compromises the security of information owned by an organization.
- **Security Mechanisms:** A mechanism that is designed to protect, detect or recover from a security attack.
- **Security Service:** A service that improves the security of the data of an organization. These services are meant to work against security attacks, using some security mechanisms to provide the service.

5. Security Attacks in MANETS

Mainly attacks in MANETS's can be divided into two ways. They are shown in figure 2.

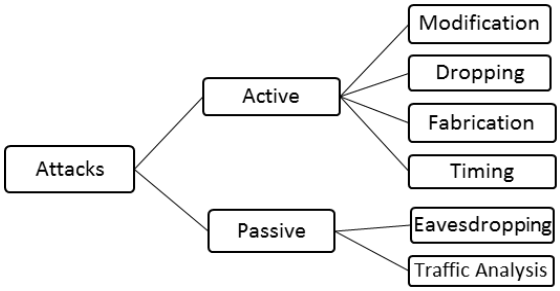

Figure 2: Security Attacks in MANET's

1. **Passive attacks:** In a passive attack an illegal node display and aims to find out information about the network. The attackers do not otherwise need to communicate with the network. Hence, they do not disturb communications or cause any direct harm to the network. However, they can be used to get information for upcoming harmful attacks. Examples of passive attacks are eavesdropping and traffic analysis.

    - **Eavesdropping Attacks**, also identified as disclosure attacks, are passive attacks by external or internal nodes. The attacker can analyze broadcast messages to reveal some valuable information about the system. Solutions protecting the radio interface from attacks such as eavesdropping (and jamming) attacks have been proposed in the literature, e.g. Spread field communication and frequency hopping.
    - **Traffic Analysis** is not essentially a completely passive activity. It is perfectly possible to involve in protocols, or search for to irritate communication among nodes. Attackers may employ methods such as RF direction finding, traffic rate analysis, and time-correlation checking.

2. **Active Attacks:** These attacks cause illegal state changes in the network such as denial of service, modification of packets, and the like. These attacks are normally launched by users or nodes with authorization to control within the network. We categorize active attacks into four groups: dropping, modification, fabrication, and timing attacks. It should be noted that an attack can be classified into more than one group.

    - **Dropping Attacks:** Malicious or selfish nodes intentionally drop whole packets that are not designed for them. While malicious nodes, target to disturb the system connects, selfish nodes aim to reserve their resources. Reducing attacks can avoid end-to-end communications among nodes, if the dropping node is at a critical point. It might also decrease the network performance by causing data packets to be retransmitted, new ways to the endpoint to be exposed.
    - **Modification Attacks:** Insider attackers modify packets to disturb the network. For example, in the sinkhole attack the attacker tries to attract closely all traffic from a specific zone through a cooperated node by creating the cooperated node attractive to additional nodes. Sinkhole attack is shown in figure 3. It is especially effective in routing protocols that use to advertise information such as remaining energy and an adjacent node to the end of the route detection procedure. A sinkhole attack can be used as a basis for extra attacks like dropping and selective sending attacks. A black hole attack is like a sinkhole attack that attracts traffic over itself and uses it as the basis for more attacks. The achievement is to avoid packets being sent to the endpoint. If the black hole is a virtual node or a node outside the network, it is inflexible to notice.

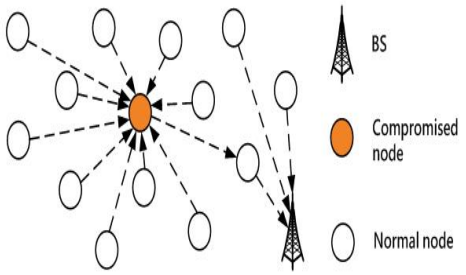

Figure 3: Sinkhole Attack

(Source:http://2we26u4fam7n16rz3a44uhbe1bq2.wpengine.netdna-cdn.com/wp-content/uploads/SinkholeAttack.jpg)

- **Fabrication Attacks:** The attacker forges network packets. In fabrication attacks are categorized into "active forge" in which attackers send fake messages without getting any associated message and "forge reply" in which the attacker sends fake route answer messages in reply to related genuine route request messages.

- **Timing Attacks:** An attacker attracts additional nodes by causing it to seem nearer to those nodes than it certainly is. Denial-of-Service (DOS) attacks, rushing attacks, and hello flood attacks use this method. Rushing attacks happen through the Route Detection phase. In all current on-demand protocols, a node requiring a route broadcast Route Request message and every node forwards only the main received Route Request in order to limit the overhead of message flooding. If the Route Request forwarded by the attacker reaches first at the endpoint, routes, including the attacker will be exposed instead of legal routes. Rushing attacks can be accepted in numerous methods: by disregarding delays at MAC or routing layers, by wormhole attacks, by keeping additional nodes' broadcast queues full, or by communicating packets at an advanced wireless transmission power. Refer figure 4 for wormhole attack. The hello flood attack is alternative attack that creates the adversary attractive for several routes.

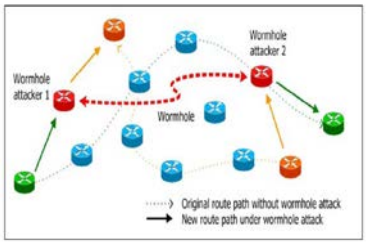

Figure 4: Wormhole Attack
(Source: http://www.mdpi.com/sensors/sensors-09-05022/article_deploy/html/images/sensors-09-05022f1-1024.png)

6. Conclusion

Mobile ad hoc and sensor network is a new concept in wireless technology. In this research paper discussed what MANET is. When Compare with other traditional mobile wireless network ad hoc network has no existing fixed infrastructure and there is no centralized administration. And the network topology move frequently, when talking about security wireless network has less security than wired networks because wireless network has limited resources. Then handling security is a major part in this kind of network. Security can divided into different parts. They are what the security system which already used in MANETS is. What are the security issues and what are the security challenges. The challenges can categorize as limitations of mobile nodes. This occurs because of short battery life and limited capacities. And some challenges occur due to limitations of the physical layer. Those challenges are limited wireless range, packet loss during transmission, etc. Finally discussed the solutions to prevent security issues in mobile ad hoc networks. It uses signaling packets to avoid collision. They are RTS (request to send) and CTS (Clear to send).

7. Future Work

Standardized intrusion detection techniques can be used and the techniques which already have gotten further improved are some of the points that can be further researched and explored in the future. However Ad hoc is the current evaluation for state of-the-art wireless security solutions. There are some drawbacks which must be improved. There are given below:

- Large scale wireless network setting will have Lacks of effective analytical tools;
- Find out which start, misses behaving inside the network and block an authenticated user;
- Security strength among the multidimensional trade-offs;
- Communication overhead;
- Computational complexity;
- Energy consumption;
- Scalability still remains largely unexplored.

In this research paper mainly discussed the security challenges and attacks in MANET and represented some analytics in them. MANET is self-organized network and there is no centralized administration. Then the encryption, authentications are challengeable. Most important challenges are the Key distribution and control unit. Dynamic network

topology, in MANET is created and maintain clusters in highly challengeable. Redundancy approaches, generate lots of duplicated packets and its waste node's resources. It increases congestion and then packet lost. Choosing number of duplicated paths effectively is based on risk level. Another challengeable issue is combining this approach with some other approaches in order to detect malicious nodes.

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