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EAACK: Secure IDS for Wireless Sensor Networks

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Abstract: The migration to wireless network from wired network has been a global trend in the past few decades.The open medium and wide distribution of nodes make MANET vulnerable to malicious attackers. A new technique EAACK (Enhanced Adaptive Acknowledgement) method designed for MANET was proposed for intrusion detection.EAACK demonstrates higher malicious-behavior-detection rates in certain circumstances while does not greatly affect the network performances.

Keywords: Keywords- EAACK (Enhanced Adaptive Acknowledgement), IBOOS (Identity Based Online/Offline Signature),SACK (Selective Acknowledgement), Packet dropping, Watchdog scheme.

I. INTRODUCTION

In the recent years, wireless technology has enjoyed a tremendous rise in popularity and usage, in the domain of networking. In MANETs, the participating nodes do not rely on any existing network infrastructure. A mobile ad hoc network consisted of wireless nodes that can be rapidly deployed as a multi-hop packet radio network without the aid of any existing network infrastructure or centralized administration. Therefore, the interconnections between nodes are capable of changing on continual and arbitrary basis. Nodes within with in a radio range communicate directly, otherwise use intermediate parties to relay data transmissions. Ad hoc networks have a wide array of military and commercial applications. In these applications installing an infrastructure network is not possible or when the purpose of the network is too transient or even for the reason that the previous Infrastructure network was destroyed. However, this flexibility introduces new security risks. Since prevention techniques are not enough, intrusion detection systems (IDSs), which monitor system activities and detect intrusions. Intrusion detection for MANETs is a complex and difficult task mainly due to the nature of MANETs, their highly constrained nodes, and the lack of central monitoring points. so, new approaches need to be developed or else existing approaches need to be adapted for MANETs. In this paper suggest one of the intrusion detection for MANETs using EAACK.

Ad hoc network (MANET) is a collection of mobile nodes equipped with both a wireless transmitter and a receiver that communicate with each other via bidirectional wireless links either directly or indirectly. Industrial remote access and control via wireless networks are becoming more and more popular these days. One of the major advantages of wireless networks is its ability to allow data communication between different parties and still

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maintain their mobility. However, this communication is limited to the range of transmitters. This means that two nodes cannot communicate with each other when the distance between the two nodes is beyond the communication range of their own. MANET solves this problem by allowing intermediate par-ties to relay data transmissions.

This is achieved by dividing MANET into two types of networks, namely, single-hop and multi hop. In a single-hop network, all nodes within the same radio range communicate directly with each other. On the other hand, in a multi hop network, nodes rely on other intermediate nodes to transmit if the destination node is out of their radio range. In contrary to the traditional wireless network, MANET has a decentralized network infrastructure. MANET does not require a fixed infrastructure; thus, all nodes are free to move randomly .MANET is capable of creating a self-configuring and self maintaining network without the help of a centralized infrastructure, which is often infeasible in critical mission applications like military conflict or emergency recovery. Minimal configuration and quick deployment make MANET Ready to be used in emergency circumstances where an infrastructure is unavailable or unfeasible to install in scenarios like natural or human-induced disasters, military conflicts, and medical emergency situations. Owing to these unique characteristics, MANET is becoming more and more widely implemented in the industry. However, considering the fact That MANET is popular among critical mission applications; network security is of vital importance. Unfortunately, the open medium and remote distribution of MANET make it vulnerable to various types of attacks.

For example, due to the nodes' lack of physical protection, malicious attackers can easily capture and compromise nodes to achieve attacks. In particular, considering the fact that most routing protocols in MANETs assume that every node in the network behaves cooperatively with other nodes and presumably not malicious, attackers can easily compromise MANETs by inserting malicious or non cooperative nodes into the network. Furthermore, because of MANET's distributed architecture and changing topology, a traditional centralized monitoring technique is no longer feasible in MANETs Enhanced Adaptive Acknowledgment (EAACK) specially designed for MANETs. Proposed approach

EAACK is designed to tackle three of the weakness of watchdog scheme, false misbehavior and collision.

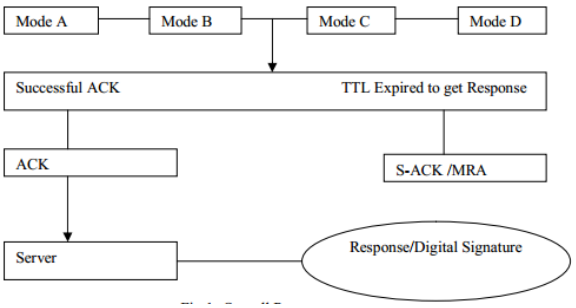

Fig 1. Process of EAACK

2. BACKGROUND

2.1 Intrusion Detection in MANETs

In traditional wired networks many Intrusion Detection Systems has been proposed, where all traffic must go through hub, switches, routers, or gateways. Hence, Intrusion Detection Systems can be added to and implemented in these devices easily. On the other hand, Mobile Adhoc Networks do not have such devices. Moreover, the medium is wide open, so both legitimate and malicious users can access it. Furthermore, there is no clear separation between normal and unusual activities

in a mobile environment. Since nodes can move arbitrarily, false routing information could be from a compromised node or a node that has outdated information. Thus, the current Intrusion Detection Systems techniques on wired networks cannot be applied directly to Mobile Adhoc Networks. Many Intrusion Detection Systems have been proposed to suit the characteristics of MANETs.

2.2 Overseer or Watchdog

The main of the Overseer mechanism is to improve the throughput of the network with the presence of malicious Nodes. The Overseer scheme is of two types namely Overseer and pathrater. Overseer serves as intrusion Detection for Mobile Adhoc Network and responsible for detecting malicious node misbehavior in the network. Watchdog detects malicious node misbehaviors by listen in to its next hop's transmission. If a Watchdog node overhears that its next node fails to forward the packet within a predefined time period, it increases its failure counter. Whenever a node's failure counter exceeds a predefined threshold, the Watchdog node reports it as misbehaving. At the same time, watchdog maintaining a buffer of recently sent packets and comparing each overheard packet with the packet in the buffer. A data packet is cleared from the buffer when the watchdog overhears the same packet being forwarded by the next-hop node over the medium. If a data packet remains in the buffer for too long, the watchdog scheme accuses the next-hop neighbor to be misbehaving.

2.3. Issues in Intrusion Detection System

Even though there are many proposed IDSs for wired networks, MANET's specific features make conventional IDSs ineffective and inefficient for this new environment. Researchers have been working recently on developing new IDSs for MANETs or changing the current IDSs to be suitable to MANETs. There are some new issues which should be taken into account when a new ID is being designed for MANETs.

• Lack of central points: MANETs do not have any entry points such as routers, gateways, etc. present in wired network. These can be used to monitor all network traffic that passes through them. A node in a MANET can see only a portion of a network: the packets it sends or receives together with other packets within its radio range

3. RELATED WORKS

The Watchdog/Pathrater is a solution to the problem of selfish (or ―misbehaving‖) nodes in MANET. The system introduces two extensions to the DSR algorithm to mitigate the effects of routing misbehavior: the Watchdog, to detect the misbehaving nodes and the Pathrater, to respond to the intrusion by isolating the selfish node from the network operation.

A. Intrusion Detection system in MANETS:

As discussed before, due to the limitations of most MANET routing protocols, nodes in MANETs assume that other nodes always cooperate with each other to relay data. This assumption leaves the attackers with the opportunities to achieve significant impact on the network with just one or two compromised nodes. To address this problem, Intrusion Detection System (IDS) should be added to enhance the security level of MANETs. If MANET can detect the attackers as soon as they enter the network, we will be able to completely eliminate the potential damages caused by compromised nodes at first time. IDSs usually act as the second layer in MANETs, and it is a great complement to existing proactive approaches and presented a very thorough survey on contemporary IDSs in MANETs. In this section, we mainly describe three existing approaches, namely, Watchdog, TWOACK and AACK.

B. Watchdog:

Watchdog that aims to improve throughput of network with the presence of malicious nodes. In fact, the watchdog scheme is consisted of two parts, namely Watchdog and Path rater. Watchdog serves as an intrusion detection system for MANETs. It is responsible for detecting malicious nodes misbehaviors in the network. Watchdog detects malicious misbehaviors by promiscuously listens to its next hop's transmission.

In this case, the Path rater cooperates with the routing protocols to avoid the reported nodes in future transmission. Many following researches and implementations have proved that the Watchdog scheme to be efficient. Furthermore, compared to some other schemes, Watchdog is capable of detecting malicious nodes rather than links. Many MANET IDSs are either based on or developed as an improvement to the Watchdog scheme. Watchdog scheme fails to detect malicious misbehaviors with the presence of ambiguous collisions, Receiver collisions, limited transmission power, false misbehaviour report,collusion,Partial dropping.

C. TWOACK:

TWOACK is neither an enhancement nor a Watchdog based scheme. Aiming to resolve the receiver collision and limited transmission power problems of Watchdog, TWOACK detects misbehaving links by acknowledging every data packets transmitted over each three consecutive nodes along the path from the source to the destination.

The working process of TWOACK is demonstrated in Fig. 1, node A first forwards packet 1 to node B, and then node B forwards Packet 1 to node C. When node C receives Packet 1, as it is two hops away from node A, node C is obliged to generate a TWOACK packet, which contains reverse route from node A to node C, and sends it back to node A. TWOACK scheme successfully solves the receiver collision and limited transmission power problems posed by Watchdog. However, the acknowledgement process required in every packet transmission process added a significant amount of unwanted network overhead. Due to the limited battery power nature of MANETs, Such redundant transmission process can easily degrade the life span of the entire network.

D. AACK:

It is based on TWOACK Acknowledgement (AACK) similar to TWOACK,AACK is an acknowledgement based network layer scheme which can be considered as a combination of a scheme call ACK (identical to TWOACK) and an end-to-end acknowledgement scheme called ACK. Compared to TWOACK, AACK significantly reduced network overhead while still capable of maintaining or even surpassing the same network throughput. Source node S will switch to TACK scheme by sending out a TACK packet. The concept of adopting a hybrid scheme in AACK greatly reduces the network overhead, but both TWOACK and AACK still suffer from the problem that they fail to detect malicious nodes with the presence of false misbehavior report and forged acknowledgement packets.

Problem Definitions

Our proposed approach EAACK is designed to tackle three of the six weaknesses of Watchdog scheme, namely, false misbehavior, limited transmission power, and receiver collision. As discussed in previous sections, TWOACK and AACK solve two of these three weaknesses, namely, receiver collision and limited transmission power.

4. PROPOSED SYSTEM

EAACK is an acknowledgment-based IDS all three parts of EAACK, namely, ACK, S-ACK, and MRA, are acknowledgment-based detection schemes. They all rely on acknowledgment packets to detect misbehaviors in the network. Thus, it is extremely

important to ensure that all acknowledgment packets in EAACK are authentic and untainted. Otherwise, if the attackers are smart enough to forge acknowledgment packets, all of the three schemes will be vulnerable. EAACK requires all acknowledgment packets to be digitally signed before they are sent out and verified until they are accepted. However, we fully understand the extra resources that are required with the introduction of digital signature in MANETs. To address this concern, we implemented both DSA and RSA digital signature schemes.

The goal is to find the most optimal solution for using digital signature in MANETs. Asymmetric key cryptography overcomes the key management problem by using different encryption and decryption multiple key pairs. Having knowledge of multiple key, say the encryption key, is not sufficient enough to determine the other key - the decryption key. Therefore, the encryption key can be made public, provided the decryption key is held only by the party wishing to receive encrypted messages (hence the name public/private key cryptography). Anyone can not use the public key for others public keys and to encrypt a message, only for recipient can decrypt it. The mathematical relationship between the public/private key pair permits a general rule: any message encrypted with one key for one slot of the pair can be successfully decrypted only with that key's counterpart. To encrypt with the public key means you can decrypt only with the private key for slot by slot. The converse is also true - to encrypt with the private key means you can decrypt only with the public key.

A. Scheme description:

In this section, we describe our proposed Enhanced Adaptive Acknowledgement (EAACK) scheme in details. The approach described in this research paper is based on our previous work, where the backbone of EAACK was proposed and evaluated through implementation. In this work, we extend it with the introduction of digital signature to prevent the attacker from forging acknowledgement packets. EAACK is consisted of three major parts, namely: 1. Acknowledge (ACK), 2.Secure-Acknowledge (S-ACK) and 3. Misbehavior Report Authentication (MRA).

B. AACK:

As discussed before, ACK is basically an end-to-end acknowledgement scheme. It acts as a part of the hybrid scheme in EAACK, aiming to reduce network overhead when no network misbehavior is detected. In Fig.3, in ACK mode, node S first sends out an ACK data packet ad1 P t o the destination node D. If all the intermediate nodes along the route between node S and node D are cooperative and node D Successfully receives ad1 P, node D is required to send back an ACK acknowledgement packet ak1 P along the same route but in a reverse order.

C. S-ACK:

S-ACK scheme is an improved version of TWOACK scheme. The principle is to let each three consecutive nodes work in a group to detect misbehaving nodes. For each three consecutive nodes in the route, the third node is required to send an S-ACK acknowledgement packet to the first node. The intention of introducing S-ACK mode is to detect misbehaving nodes in the presence of receiver collision or limited transmission power. in S-ACK mode, the three consecutive nodes (i.e. F1, F2 and F3) work in a group to detect misbehaving nodes in the network. Node F1 first sends out S-ACK data packet to node F2.

D. MRA:

The Misbehavior Report Authentication (MRA) scheme is designed to resolve the weakness of

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Watchdog when it fails to detect misbehaving nodes with the presence of false misbehavior report. False misbehavior report can be generated by malicious attackers to falsely report that innocent nodes as malicious. This attack can be lethal to the entire network when the attackers break down sufficient nodes and thus cause a network division. The core of MRA scheme is to authenticate whether the destination node has received the reported missing packet through a different route. To initiate MRA mode, the source node first searches its local knowledge base and seeks for alternative route to the destination node. If there is none other exists, the source node starts a DSR routing request to find another route.

E. Digital Signature:

As discussed before, EAACK is an acknowledgement based IDS. All three parts of EAACK, namely: ACK, SACK and MRA are acknowledgement based detection schemes. They all rely on acknowledgement packets to detect misbehaviors in the network. Thus, it is extremely important to ensure all acknowledgement packets in EAACK are authentic and untainted. Otherwise, if the attackers are smart enough to forge acknowledgement Packets, all of the three schemes will be vulnerable.

Attack Detection Techniques

The 2ACK scheme solves the problems of ambiguous collisions, receiver collisions, and limited transmission power: End-to-end Acknowledgment Schemes: Such acknowledgments are sent by the end-receiver to notify the sender about the reception of data packets up to some locations of the continuous data stream. The Selective Acknowledgment (SACK) technique is used to acknowledge out-of-order data blocks. The 2ACK technique differs from the ACK and the SACK schemes in the TCP protocol in the following manner: the 2ACK scheme tries to detect those misbehaving nodes which have agreed to forward data packets for the source node but refuse to do so when data packets arrive TCP, on the other hand, uses ACK and SACK to measure the usefulness of the current route and to take appropriate action. For example, congestion control is based on the reception of the ACK and the SACK packets.

4. RESULT ANALYSIS

Figure 1 shows malicious node drop all the packets that pass through it. we observe that all acknowledgment based IDSs perform better than the Watchdog scheme. Our proposed scheme EAACK surpassed Watchdog's performance by 21% when there are 20% of malicious nodes in the network. From the results, we conclude that acknowledgment-based schemes, including TWOACK, AACK, and EAACK, are able to detect misbehaviors with the presence of receiver collision and limited transmission power. However, when the number of malicious nodes reaches 40%, our proposed scheme EAACK's performance is lower than those of TWOACK and AACK.

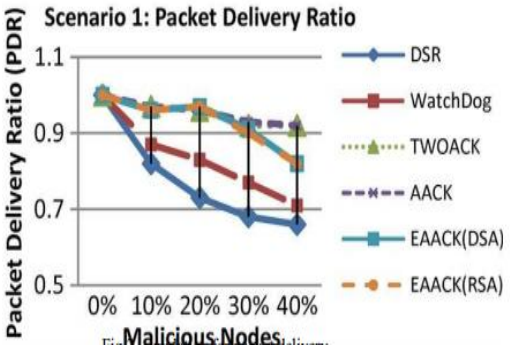

Fig 2. Simulation for Packet Delivery

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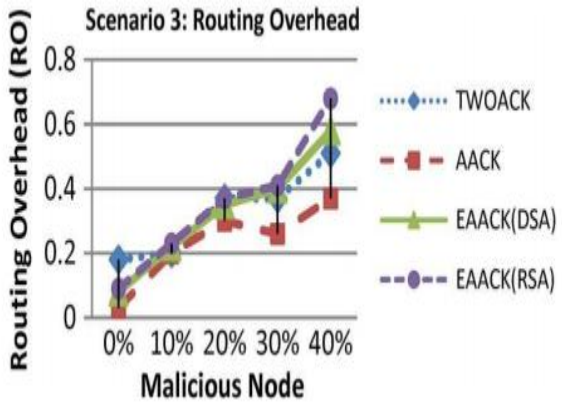

Fig 3. Routing Overhead

5. CONCLUSION

Packet-dropping attack has always been a major threat to the security in MANETs. In this research paper, we have proposed a novel IDS named EAACK protocol specially de-signed for MANETs and compared it against other popular mechanisms in different scenarios through simulations. The results demonstrated positive performances against Watchdog, TWOACK, and AACK in the cases of receiver collision, limited transmission power, and false misbehaviour report .The attackers from initiating forged acknowledgment attacks, we extended our research to incorporate digital signature in our proposed scheme. Al-though it generates more ROs in some cases, as demonstrated in our experiment, it can vastly improve the network's PDR when the attackers are smart enough to forge acknowledgment packets. We think that this trade off is worthwhile when network security is the top priority. In order to seek the optimal DSAs in MANETs, we implemented both DSA and RSA schemes in our simulation. Eventually, we arrived to the conclusion that the DSA scheme is more suitable to be implemented in MANETs

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