An Enhanced Adaptive Acknowledgement Method to Provide Security in Manets

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Abstract

In Wireless Sensor Networks there was a new facility like mobility and scalability through which a lot of demand for wireless sensor networks compared with wired networks .With this great features a lot of users have been migrating to wireless sensor networks from wired network .As this is increasing its popularity in spreading almost all around the world, on the other side there was many intruders who try to attack the data transmission during WSN communication. MANET is considered to be one of the best media among all WSN.On the contrary to traditional network architecture, MANET does not require a fixed network infrastructure; every single node works as both a transmitter and a receiver. Nodes communicate directly with each other when they are both within the same communication range. Otherwise, they rely on their neighbors to relay messages. The self-configuring ability of nodes in MANET made it popular among critical mission applications like military use or emergency recovery. As the MANETS have open network facility there was a lot of hackers who try to attack the data during transmission. Till now there was no proper device or mechanism to identify the suspicious objects or intruders in wireless sensor networks .So in this paper we have implemented a new system for identifying the Hackers or intruders known as Intrusion Detection System (IDS where this new intrusion-detection system named Enhanced Adaptive ACKnowledgment (EAACK) specially designed for MANETs. Compared to old approaches, EAACK demonstrates higher – behavior-detection rates in certain circumstances while does not greatly affect the network performances.

Keywords

Digital Signature Algorithm (DSA), Enhanced Adaptive Acknowledgment (AACK) (EAACK), WSN, IDS, MANET's.

1. Introduction

A Wireless Sensor Network may be vary in size when compared with different type of sensors just like of a shoebox down to the size of a grain of dust. The amount for purchasing of single sensor nodes is similarly variable in its price, ranging from a few to hundreds of dollars, depending on the complexity of the individual sensor nodes. While deploying any sensor some valuable resources like energy, memory, computational speed and communication bandwidth mainly depends on size and cost of the sensor what we use. The topology (I.e. arrangement of nodes) of the WSNs can vary from a basic star network to an advanced mesh network. The propagation technique between the nodes of the wireless network can be routing or flooding [1], [2].

A Wireless Sensor Network (WSN) is a collection of several nodes ranges from a few to several hundreds and even thousands of nodes, where each and every group of nodes is connected either to single sensor or group of sensors. Sensor network typically has several parts which is clearly shown in figure 1.

1. A radio transceiver device with an inbuilt internal antenna or device connected to an external antenna.

2. A microcontroller

3. An electronic circuit board for interfacing mainly with the sensors and an energy source, usually a battery or an embedded form of energy harvesting.

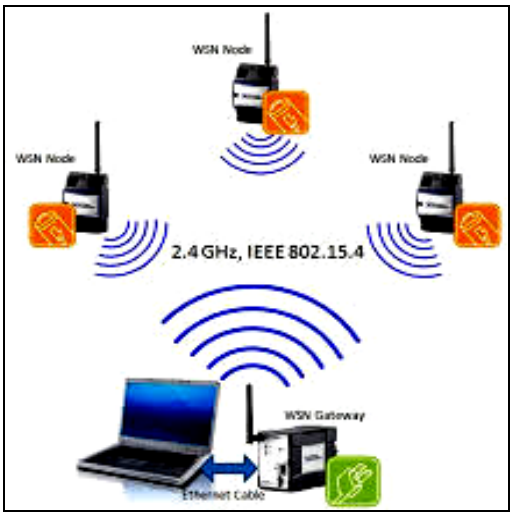


Fig.1. Represents the wireless sensor network

In recent days as there was a huge demand for wireless sensor networks in a variety of applications, a lot of research efforts have been made to develop sensor hardware and network architectures in order to effectively deploy WSNs.For the general purpose network deployment, normal WSN cannot able to fulfill the needs like sensing range, transmission range, and bandwidth range for sensing the data remotely. To achieve this, it is very crucial to identify the impact parameters of network on its performance w.r.t application specifications. In CSE and telecommunications, wireless sensor networks are an active research area with numerous workshops and conferences arranged each year for the improvement of its performance[3],[4].

Owing to these unique characteristics, MANET is becoming more and more widely implemented in the industry [14]. 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 [5], 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. In such case, it is crucial to develop an intrusion-detection system (IDS) specially designed for MANETs. Many research efforts have been devoted to such research topic [6]–[9], [15], [16]

2. Related Work

In this section, we will find the information which was very near to our current intruder detection system in detail. We will mainly discuss about the new IDS system which automatically detects the intruder who is available in the network.

Intrusion Detection System

An Intrusion detection system (IDS) is internet software which is mainly deployed on the hardware designed to detect any unwanted attempts

to access, manipulating, and/or disabling of computer mainly through a network. An intrusion detection system is mainly used to identify several types of malicious behaviors that can easily compromise the security and trust of a computer system. Some of the attacks include network attacks against vulnerable services, host based attacks such as privilege escalation attack, unauthorized logins attack and attempting to access some invalid files like viruses and worms.

IDS are mainly composed of several components:

1. Sensors: This is used for generating security events.

2. Console: Which is used to monitor events and alerts, while controlling the sensors.

3. Central Engine

Which is mainly used for recording the events logged by the sensors in a database and use a system of rules to generate alerts from security events received.

Preliminary Approaches or Methods of MANET's

The following is the preliminary approaches that are used for MANETS, namely,

I. TWOACK Approach [15], and
II. Adaptive ACKnowledgment (AACK) Approach.

I) TWOACK Approach:

With respect to the six weaknesses of the Watchdog scheme, many researchers proposed new approaches to solve these issues. TWOACK proposed by Liu *et al.* [16] is one of the most important approaches among them. On the contrary to many other schemes, 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 packet transmitted over every three consecutive nodes along the path from the source to the destination. Upon retrieval of a packet, each node along the route is required to send back an acknowledgment packet to the node that is two hops away from it down the route. TWOACK is required to work on routing protocols such as Dynamic Source Routing (DSR**)** [11]. The working process of TWOACK is shown in Fig. 2:

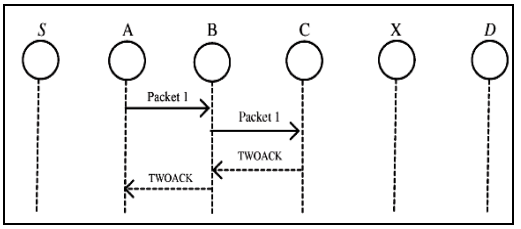


Fig. 2 TWOACK scheme: Each node is required to send back an acknowledgment packet to the node that is two hops away from it.

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. The retrieval of this TWOACK packet at node A indicates that the transmission of Packet 1 from node A to node C is successful. Otherwise, if this TWOACK packet is not received in a predefined time period, both nodes B and C are reported malicious. The same process applies to every three consecutive nodes along the rest of the route.

II) AACK Approach:

Based on TWOACK, Sheltami *et al.* proposed a new scheme called AACK. Similar to TWOACK, AACK is an acknowledgment-based network layer scheme which can be considered as a combination of a scheme called TACK (identical to TWOACK) and an end-to-end acknowledgment scheme called ACKnowledge (ACK).

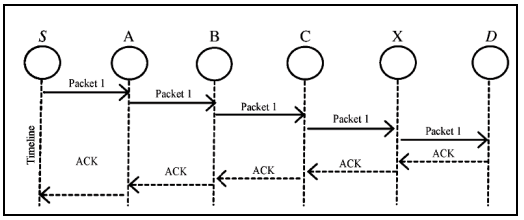


Fig. 3. ACK scheme: The destination node is required to send acknowledgment packets to the source node.

Compared to TWOACK, AACK significantly reduced network overhead while still capable of maintaining or even surpassing the same network throughput. The end-to-end acknowledgment scheme in ACK is shown in Fig. 3.

3. Proposed EAACK Scheme

In this section, we describe our proposed EAACK scheme in detail. The approach described in this research paper is based on our previous work [12], where the backbone of EAACK was proposed and evaluated through implementation. In this paper, we extend it with the introduction of digital signature to prevent the attacker from forging acknowledgment packets.EAACK is consisted of three major parts, namely, ACK, secure ACK (S-ACK), and misbehavior report authentication (MRA). In order to distinguish different packet types in different schemes, we included a 2-b packet header in EAACK. According to the Internet draft of DSR [11], there is 6 b reserved in the DSR header. In EAACK, we use 2 b of the 6 b to flag different types of packets. Details are listed in Table I.

Fig. 4 (shown later) presents a flowchart describing the EAACK scheme. Please note that, in our proposed scheme, we assume that the link between each node in the network is bidirectional. Furthermore, for each communication process, both the source node and the destination node are not malicious. Unless specified, all acknowledgment packets described in this research are required to be digitally signed by its sender and verified by its receiver.

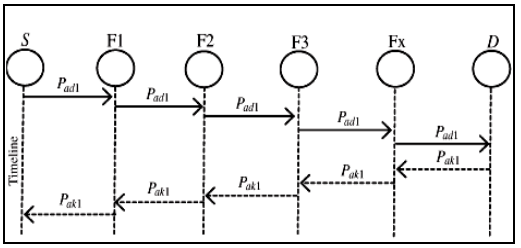


Fig. 4. System control flow: This figure shows the system flow of how the EAACK scheme works.

3.1 ACK

As discussed before, ACK is basically an end-to-end acknowledgment 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. 6, in ACK mode, node S first sends out an ACK data packet *Pad*1 to the destination node D. If all the intermediate nodes along the route between nodes S and D are cooperative and node D successfully receives *Pad*1, node D is required to send back an ACK acknowledgment packet *Pak*1 along the same route but in a reverse order. Within a predefined time period, if node S receives *Pak*1, then the packet transmission from node S to node D is successful. Otherwise, node S will switch to S-ACK mode by sending out an S-ACK data packet to detect the misbehaving nodes in the route.

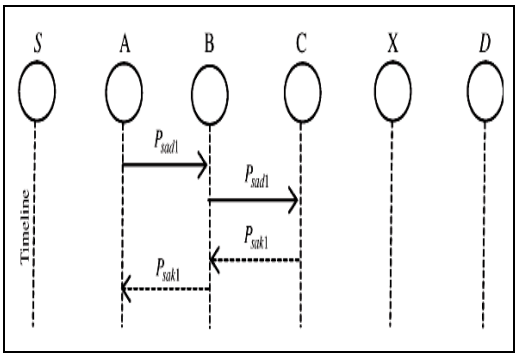


Fig. 5. ACK scheme: The destination node is required to send back an acknowledgment packet to the source node when it receives a new packet.

3.2 S-ACK

The S-ACK scheme is an improved version of the TWOACK scheme proposed by Liu *et al.* [16]. The principle is to let every three consecutive nodes work in a group to detect misbehaving nodes. For every three consecutive nodes in the route, the third node is required to send an S-ACK acknowledgment 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. As shown in Fig. 7, 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 *Psad*1 to node F2. Then, node F2 forwards this packet to node F3. When node F3 receives *Psad*1, as it is the third node in this three-node group, node F3 is required to send back an S-ACK acknowledgment packet *Psak*1 to node F2. Node F2 forwards *Psak*1 back to node F1. If node F1 does not receive this acknowledgment packet within a predefined time period, both nodes F2 and F3 are reported as malicious. Moreover, a misbehavior report will be generated by node F1 and sent to the source node S. Nevertheless, unlike the TWOACK scheme, where the source node immediately trusts the misbehavior report, EAACK requires the source node to switch to MRA mode and confirm this misbehavior report. This is a vital step to detect false misbehavior report in our proposed scheme.

3.3 MRA

The MRA scheme is designed to resolve the weakness of Watchdog when it fails to detect misbehaving nodes with the presence of false misbehavior report. The false misbehavior report can be generated by malicious attackers to falsely report 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 the MRA mode, the source node first searches its local knowledge base

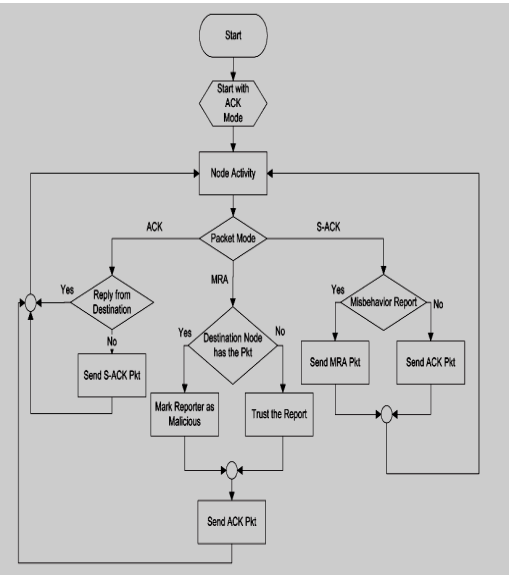


Fig.6. S-ACK scheme: Node C is required to send back an acknowledgment packet to node A.

and seeks for an alternative route to the destination node. If there is no other that exists, the source node starts a DSR routing request to find another route. Due to the nature of MANETs, it is common to find out multiple routes between two nodes.

By the adoption of MRA scheme, EAACK is capable of detecting malicious nodes despite the existence of false misbehavior report.

4. Implementation Modules

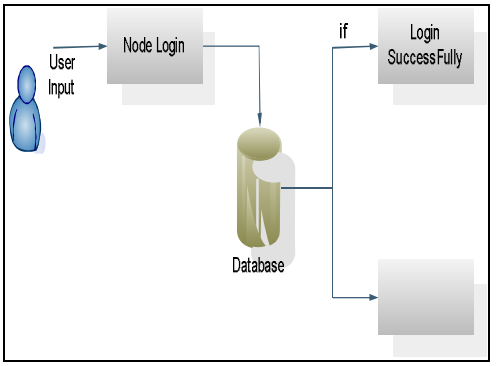
Implementation is the stage where theoretical design is converted into programmatically design. The implementation is mainly divided into several modules for implementing the application. The following application contains 6 modules. Now we can discuss about those modules in detail.

1) Node Creation Module
2) Source Node Selection and Encryption Module

3) Key generation and MAC generation Module
4) ACK Module
5) S-ACK Module
6) Misbehave Report Authentication and Verification Module

1) Node Creation Module

In this module, we create Nodes and form a Network. Users enter the Node Name, IpAddress, and port number, of the node to register in the Database. While entering the next node the user must check the database for that node exists or new one.



2) Source Node Selection and Encryption Module

The users to select the source node then browse the content to provide the source node Authentication. A security solution should scale for large group of receivers and long multi-hop paths. Thus, a solution that is based on a distinct authentication key for every receiver will introduce prohibitive overhead to the message and consume significant portion of the available bandwidth. Moreover, the solution should scale for large number of senders by requiring reasonable memory resources at the individual receivers for storing authentication keys. Finally, it is desired to enable the validation of every packet without excessive delay and independent of the other packets.

3) Key generation and MAC generation Module

The source generates the keys at the time of establishing session. The keys will be securely transmitted to the head of every packet that hosts one or multiple receivers. The multicast message is then transmitted to the authenticate the source and then deliver the message to the intended receivers. After data encryption the key generation and MAC generation are generated then send the data to the destination node via intermediate node.
Finally, verify the content.

4) ACK Module

In this acknowledgement mode to select the source node then send the Ack Data Packet through the intermediate node to verify the data then destination node. The destination node to receive the data then back to send ack to the source node..In this ACK node, node S first sends out an ACK data packet *Pad*1 to the destination node D. If all the intermediate nodes along the route between nodes S and D are cooperative and node D successfully receives *Pad*1, node D is required to send back an ACK acknowledgment packet *Pak*1 along the same route but in a reverse order. Within a predefined time period, if node S receives *Pak*1, then the packet transmission from node S to node D is successful. Otherwise, node S will switch to S-ACK mode by sending out an S-ACK data packet to detect the misbehaving nodes in the route.

5) S-ACK Module

In this mode source node packet are forward to the destination. it can find the misbehave node then send report to MRA. The S-Ack Mode consecutive three nodes work in a group to detect misbehaving nodes in the network. Node F1 first sends out S-ACK data packet *Psad*1 to node F2. Then, node F2 forwards this packet to node F3. When node F3 receives *Psad*1, as it is the third node in this three-node group, node F3 is required to send back an S-ACK acknowledgment packet *Psak*1 to node F2. Node F2 forwards *Psak*1 back to node F1. If node F1 does not receive this acknowledgment

packet within a predefined time period, both nodes F2 and F3 are reported as malicious.

6. Misbehave Report Authentication and Verification Module

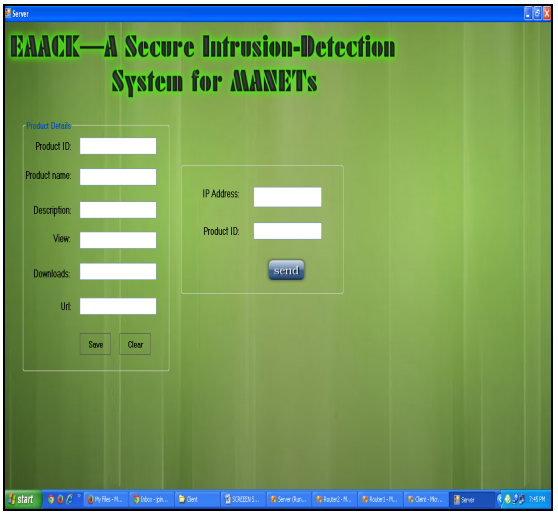
To initiate the MRA mode, the source node first searches its local knowledge base and seeks for an alternative route to the destination node. The destination has the packet the report as trust the packet are correct and another way mark report as malicious then send Ack Packet to the Source node.

5. Experimental Results

We have implemented the proposed concept on .NET Platform in order to show the performance of our proposed EAACK scheme is very accurate in identification of attacker when compared with various existing models.

5.1 Main Window

The below window clearly shows that this is the main window for entering into the application, this was designed with C# as a front End user interface.

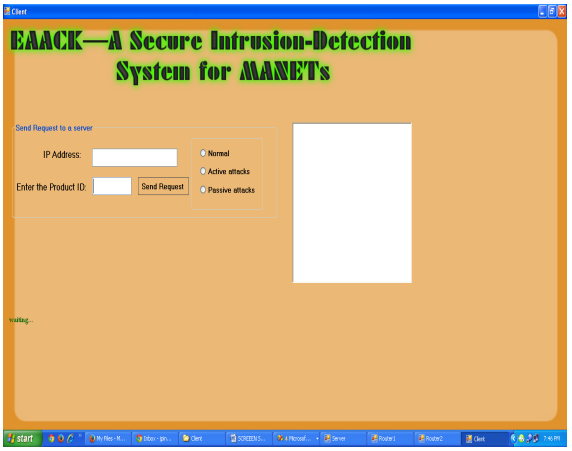


5.2 Router 1 Window

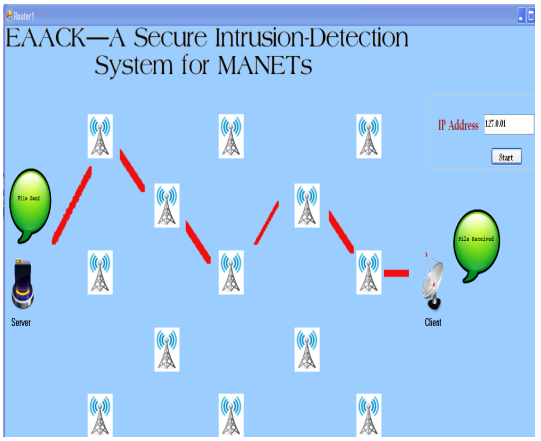
The above window clearly justifies that this is a router1 window through which the client can communicate with the server window.

5.3 Destination Window

The below window clearly represents that this is the client window which is used for interacting with the routers and in turn with server for getting the response.



ACK Identification Window



In the above window the ACK is identified at router node ,if there was any attack occurred this will be also identified at this router level only.

6. Conclusion

In this paper, we have proposed a novel IDS named EAACK protocol specially designed 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 misbehavior report. Furthermore, in an effort to prevent the attackers from initiating forged acknowledgment attacks, we extended our research to incorporate digital signature in our proposed scheme. Although 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 tradeoff 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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