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# Comparative study of various Distributed Intrusion Detection Systems for WLAN

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*Abstract -* In any information system intrusions are the activities that damage the security and integrity of the system. In this paper we focus on wireless network, intrusions in wireless network (WLAN) and different Distributed Intrusion Detection Systems which are used to detect these attacks or intrusions. The rapid enhancement in wireless network has changed the level of network security. So, past of protecting the network with the firewalls are not sufficient to maintain network security in wireless local area network. There are different intrusion detection techniques which are used for identifying the various types of intrusions in wireless local area network. In this paper, we compare the various Distributed intrusion detection Systems used for detecting attacks in wireless network and also make a comparison table of these DIDS depending upon the performance. This comparison table will very helpful in designing better intrusion detection systems for detecting and preventing of vulnerabilities in wireless network.

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# Comparative study of various Distributed Intrusion Detection Systems for WLAN

Opinder Singh [α] & Dr Jatinder Singh [σ]

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## I. Introduction

Wireless networks are becoming so popular for many applications because they provide communication between different systems without predetermined infrastructure. Due to this flexibility new security risks are introduced in wireless network. The wireless network is dynamic in nature so there are number of challenges in maintaining security in wireless network. In wireless network there is need of defense schemes which are stronger, efficient and flexible. Intrusions in an information system are the processes or activities that damage the security policy of system. Intrusion detection is the process detecting and reporting unauthorized or unapproved network activity. It is used to identify intrusions or attacks against the system. Intrusion detection system (IDSs) collects and scrutinizes the data to recognize computer system and network intrusions or mishandlings. Conventional IDSs have been designed for wired systems and networks to identify intrusions or attacks. Of late, wireless network have been concentrated for employing the IDSs Constructed. Monitoring, analyzing user and system activities, identifying abnormal network activities and detecting policy violations for WLANs are the functions of these wireless IDSs. There are a lot of chances of attacks in WLANs due to dynamic topology, absence of infrastructure and centralized administration. Wireless IDSs collect all local wireless transmissions and rely either on predefined signatures [1] or on anomalies in the traffic [3] to produce alerts or alarms. In this paper we focus on different types of attack in wireless network, various distributed intrusion detection systems, research achievements in DIDSs fields and their comparison.

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## II. Vulnerabilities in Wireless Lan

In wired network data travel from one place to another over a dedicated physical line that is private, but in WLAN data travel from one place to another over a shared space which is not private. It means there are more chances of vulnerabilities in wireless networks as compare to wired networks. Wireless networks have characteristics like dynamic topology, absence of centralized administration and low protection of nodes. Due to dynamic topology nature of wireless network there is no boundary of wireless network, so old methods like firewall protection are not applicable for security in WLAN. Different types of vulnerabilities in WLAN are:

**a. Due to lack of infrastructure:** In wireless networks there is no fixed infrastructure which makes different security mechanism inapplicable like certification, firewall and cryptography.

**b. Vulnerability due to channels:** In wireless network fake messages can easily be injected without making physical connection with the network.

**c. Dynamic topology:** In wireless networks dynamic topology is used which require sophisticated routing protocols. Problem arises due to mobility of devices. It is very difficult to track a misbehaving device in wireless network which generate wrong routing information.

**d. Vulnerability due to nodes:** In wireless network it is not possible to protect the different nodes physically. That is why these nodes can easily be captured by an attacker.

## III. Various Type of Intrusions in Wlan

Webster's dictionary defines an intrusion as "the act of thrusting in or entering into a place or state without invitation, right or welcome", or an intrusion is an

active sequence of related events that deliberately try to cause harm such as rendering system unusable, accessing unauthorized information or manipulating information. There are different types of Attacks in WLANs [4] which are:

*a) Packet Dropping*

Packet dropping is the type of attack in which some nodes drop data packets that are forwarded to another node and violate the operation of network. Packet Dropping attacks are further of two types.

a. Black Hole Attack: It is a type of attack in which attacker or misbehaving node drops all data packets.

b. Gray Hole Attack: It is a type of attack in which misbehaving node or attackers selectively drop data packets.

*b) Worm Hole*

It is kinds of attack in which a tunnel is created between some nodes that utilize secretly transmit packets.

*c) Denial of Service*

In this type of attack nodes are blocked from sending and receiving packets to their destinations.

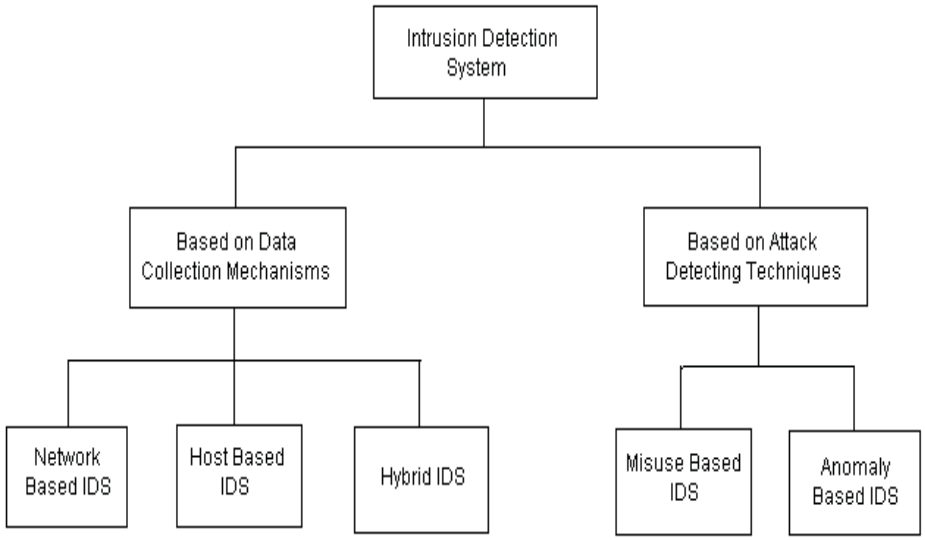


*Figure1 :* Classification of Intrusion Detection System.

*d) Routing Loop*

In this type of attack a loop is introduced in the normal path that violates the normal behavior of the network.

*e) Delay Packet Transmission*

In this type of attack an attacker nodes can transmit their own packets by delaying other's packets.

*f) Fabricated route message*

In this type of attack route messages are injected into the network that contains the malicious contents.

## IV. Classification of Intrusion Detection System

Intrusion Detection Systems (IDSs) are the software designed for detecting, blocking and reporting unauthorized activities in computer networks. An Intrusion Detection System (IDS) can be categorized into two different forms according to data collection mechanisms and attack detecting techniques [4] as shown in figure 1.

*a) Based on Data Collection Mechanism*

An IDS can be categorized into three types [6] according to the data collection method: Network Based, Host Based, Hybrid intrusion detection system. Network based intrusion detection system reside on a separate system from where it watches the network traffic, looks for indications of attacks that traverse the portion of the network. Host based intrusion detection system resides on a particular host and looks for the indications of attacks on that host. Hybrid intrusion detection system has both the functionality of Network based and Host based intrusion detection system.

i. *Network Based IDS*

Network Based IDS (NIDS) exists as a software process on a dedicated hardware. The NIDS places the network interface card on the system into promiscuous mode, i.e. the card passes all traffic on the network to

the NIDS software. The traffic is then analyzed according to a set of rules and attack signatures to determine if it is traffic of interest. If it is, an event is generated. Its attack recognition module uses four common techniques to recognize an attack signature:

- Pattern, expression or byte code matching,
- Frequency or threshold crossing
- Correlation of lesser events
- Statistical anomaly detection

Once an attack has been detected, the IDS' response module provides a variety of options to notify, alert and take action in response to the attack. Problem with NIDS is that it has high false positive rate. Another drawback is that in NIDS there is no central point to monitor whole N/W. So, it is not good for adhoc network.

ii. *Host-Based IDS*

HIDS exists as a software process on a system. HIDS examines log entries for specific information. Periodically, the HIDS process looks for new log entries and matches them up to pre-configured rules. If a log entry matches a rule, the HIDS will alarm. Today's host-based intrusion detection systems remain a powerful tool for understanding previous attacks and determining proper methods to defeat their future application. Host-based IDS still use audit logs, but they are much more automated, having evolved sophisticated and responsive detection techniques.

iii. *Hybrid IDS*

Hybrid intrusion detection system is an IDS which combine the functionality of network based sensor technology with host based agent that is capable of analyzing the network traffic only addressed to specific host where agent of hybrid IDS is installed [8].

*b) Based on Detection Techniques*

An intrusion detection system can be categorized into two different forms based on detection techniques: Signature or Misuse based and Anomaly based intrusion detection system.

i. *Signature or Misuse based IDS*

Misuse detection attempts to model abnormal behavior or signatures of known attacks. It is based on the assumption that all intrusions or attacks leave their signatures that can be detected[9,10]. Any occurrence of which clearly indicates system abuse. For Example, an HTTP request referring to the cmd.exe file may indicate an attack.

ii. *Anomaly based IDS*

Anomaly based IDS attempts to model normal behavior. Events that violate this model are considered to be suspicious. For Example, a normally passive public web server attempting to open connections to a large number of addresses may be indicative of a worm infection.

## V. Various Architecture of Intrusion Detection Systems

Depending upon the infrastructure the wireless network can be divided into two different forms either flat or multi-layer. The best architecture of IDS for a wireless network depends upon the infrastructure of that network. The different types of IDS architecture are:

*a) Standalone Architecture*

In this type of architecture Intrusion Detection System (IDS) runs on each system to find out intrusions independently. In standalone architecture there is no data exchange and no cooperation among IDSs on the network. This architecture is more appropriate for network with flat infrastructure than for network with multilayered infrastructure [13].

*b) Distributed and Collaborative Architecture*

In this type of architecture every node in wireless network takes part in intrusion detection process with the help of IDS agent running on the different nodes. In distributed and collaborative architecture IDS agent is responsible for collecting and detecting the local events and data to find out different intrusions or attacks .After identifying the intrusion IDS give response at the same time [14].

*c) Hierarchical Architecture*

This architecture is the improved version of distributed and collaborative architecture. Hierarchical architecture is well suited for infrastructure of multi-layered network. In multi layered infrastructure network is divided into clusters and cluster heads in this type of infrastructure act as control points in the same way as routers, switches and gates in wired network [15].

*d) Architecture based on mobile agent*

In this type of IDS architecture mobile agents are used to perform required task on different nodes in wireless network. In mobile agent based architecture distribution of attack detection tasks are possible. It is very best method of using mobile agents [16, 18] for detecting intrusions.

## VI. Literature Review of Various Distributed Intrusion Detection Systems (DIDS)

In 2002 Kachirski and Guha proposed an algorithm for Distributed Intrusion Detection System (DIDS)[15].This IDS is based on mobile agent technology. It is a multi-sensor IDS. In this IDS is divided into three different modules. Each of these module act as a mobile agent with some functionality like monitoring, initiating response and decision making. In this IDS functional tasks are divided into different categories and each task is assigned to different mobile agents. In this way workload is divided among different agents. This characteristic is good for wireless network.

Kachirski and goha also represent the hierarchical structure of different agents which is shown in figure 2.

Different functional tasks are performed by different agents like:

**Monitoring:** This type of task is performed by monitoring agent. There are two types of monitoring which is done by agents which are Network Monitoring and Host monitoring.

*a) Host Monitoring*

This task is performed by a host based monitor agent who hosts user activity sensors and system level sensors on every node for monitoring within node.

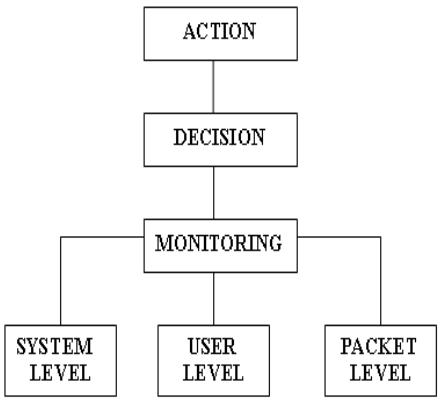


*Figure 2 :* Mobile Agent Architecture using different Layers.

*b) Network Monitoring*

In network monitoring sensors only runs on few selected nodes for monitoring at packet level to check whether packets are going through the network within their radio ranges or not.

**Action:** In this task each node acts as an action agent. When host based monitoring agent detects any unusual activity on host node then action agent gives response by blocking some user from the network or by terminating the task or process.

**Decision:** Every node in the network will decide about the attacks or intrusions threat level on the basis of host node. Some nodes in the network will gather the information regarding the intrusion and collectively make decisions for network level intrusions. In some cases when local detection agent can not able to take a decision due to some unsatisfactory evidence then it reports to decision agent for investigation .This is performed by considering packet monitoring results that are obtained from network monitoring sensor running locally. If the decision agent finds out that some node is creating intrusions in the network then action module carry out the response from that node. The wireless network is divided into different clusters with single cluster head for each. The purpose of this cluster head is to monitor the packets in cluster. It captures and investigates those packets which have their originators in same cluster. It means that decision agent and network monitoring agent both run on the cluster head. In this IDS decision agent makes decision from the information gathered by network monitoring sensor. Other nodes have no effect on decision made by decision agent. In this way attacks or intrusions can be prevented in wireless network.

In 2003 Y. Huang proposed a Cooperative and distributed intrusion detection system for wireless networks [14,19]. The architecture of intrusion detection system is divided into six different modules as shown in figure 3.

All the six modules as shown in figure work in systematic way. First of all the local data collection module accepts real time audit data. This audit data consist of user and system activities within radio range. This data is then transfer to the local detection engine for analyzing purpose. If an anomaly with strong evidence is detected by local detection engine then the IDS agent determine that the system is under attack. After detecting attack in the system it initiate a response with the help of local or global response module. Choice of response module depends upon the intrusion type, certainty of evidence and type of protocols. If an intrusion is detected without sufficient evidence then IDS

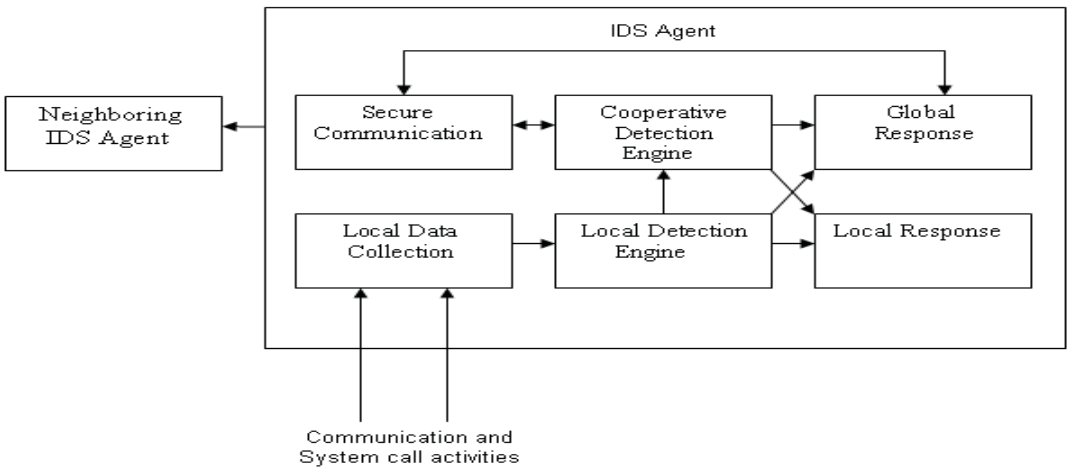


*Figure 3 :* Cooperative and Distributed Model of an Intrusion Detection System.

agent can make request to the neighboring IDS agents for cooperation through a module named as a cooperative detection engine. This module will help for communicating with other neighboring agents through another module named as a secure communication module.

In 2007 R. Puttini proposed a fully Distributed Intrusion Detection System (DIDS) for mobile adhoc network[20].In this attack detection system distribution is not only on the basis of data collection but there is also execution of the detection algorithm as well as alert correlation. Each node in mobile adhoc network runs a local intrusion detection system (LIDS). All the local intrusion detection systems work with each other in cooperative manner. A mobile agent is used to compensate with the dynamic state of high mobility nodes in wireless network. In this distributed IDS R. Puttini used three types of attacks to show the IDS mechanisms. Intrusion detection is described with the help of data collection, number of attack signatures associated with this data, correlation and alert generation.

In 2010 R.Nakkeeran proposed a new model named as "Agent Based cooperative and distributive model"[16]. In this model three techniques are provided for security solution to neighboring node, current node and global network. The different modules are explained in following section.

i. *Home Agent*

This agent is part of each system and helpful in gathering information about its system which is from application layer to routing layer.

*a. Current Node*

The purpose of Home Agent in each system to monitors its system continuously. If an intrusion or attacker sends some packets to get information or try to broadcast through the system then home agent will call the classifier for finding the intrusions in the network. If there is an attack then it will filter the required system from the global network.

*b. Neighboring Node*

In a network any system can transfer the information to another system through intermediate System. Before transferring the information it send mobile agents to neighboring node for gathering information for finding out the attacks or intrusions. If there is no any intrusion in the system then it will transfer or broadcast the message to neighboring node.

*c. Data collection*

This module is used in each anomaly detection subsystem for collecting values for corresponding layer in the system. Based on the data collected during the normal scenario normal profile is created and during the attack scenario attack data is collected.

*d. Data preprocess*

The audit data is collected in some file and it is used for intrusion detection. In Data preprocess module information is processed with the test data. This preprocessing technique is used for entire layer intrusion detection systems.

ii. *Cross feature analysis for classifier sub model construction.*

iii. *Local Integration*

This module concentrate only on self system and it is responsible for finding local intrusions only. In wireless network each system follows the same method to provide secure global network.

iv. *Global integration*

This module is used for finding out the attacks for entire network. The objective of global integration is to use the results of neighboring nodes for taking decision .The results are used by response module to provide response.

Jelena Mirkovic et al. [21] have proposed a distributed system for DDoS defense, called DefCom. DefCOM nodes spam source, victim and core networks and cooperate via an overlay to detect and stop attacks. Attack response was twofold: defense nodes constrain the attack traffic, relieving victim's resources; they have also cooperated to detect legitimate traffic within the suspicious stream and ensure its correct delivery to the victim. DefCOM design has a solid economic model where networks deploying defense nodes directly benefit from their operation. DefCOM further offers a framework for existing security systems to join the overlay and cooperate in the defense. These features have created a execellent motivation for wide deployment, and the possibility of large impact on DDoS threat.

University of California, U.S. Air Force and Lawrence Livermore Laboratory jointly proposed Distributed Intrusion Detection System (DIDS)[22].DIDS incorporates a monitor on LAN, a monitor on each host and a DIDS director. Host monitor consist of two parts one is host agent and another is host event generator. The purpose of host event generator is to review the audit data from host. This audit data is used for indication of events which are responsible foe attack. This information is reported to DIDS director by Host Agent. LAN monitor consists of LAN agent and LAN event generator. LAN event generator is unlike with the host event generator. It monitors all network traffic, which include host to host connections and different resources used. LAN agent sends the information generated by LAN event generator to the DIDS director. The DIDS director is the heart of Distributed intrusion detection system. DIDS Director further consists of three components that are communication manager, user interface and an expert system. The purpose of the

| Different Distributed Intrusion Detection Systems | References of DIDS |
|---|---|
| Effective Intrusion Detection System using Multiple Sensors in Wireless Network | IDS1 |
| a Cooperative and distributed intrusion detection system for wireless networks. | IDS2 |
| a fully Distributed Intrusion Detection System(DIDS) for mobile adhoc network | IDS3 |
| Agent Based cooperative and distributive Distributed Intrusion Detection System | IDS4 |
| Distributed Intrusion Detection System for detecting denial of service (DDoS) attacks. | IDS5 |
| Distributed Intrusion Detection System(DIDS) used for wireless LAN. | IDS6 |

*Table 1 :* References of different Distributed Intrusion Detection Systems.

communication manager is to collect the information from LAN monitors and the host monitors. After collecting the information Communication manager forward this to Expert system. Expert systems do analysis of this information. The expert system in DIDS is a rule based system whose purpose is to analyze the information received from monitors and report to security officials. The user interface allows receiving different reports from expert system, a security official to review the status and can also request additional information related to security of the system. One of the main elements of DIDS is Network User Identification (NID). NID is used to establish an identifier for all users to when they are initially logged in the network. This is used because many attackers use different accounts for making attack in a network. Once a user is logged in to a network, at the same time a NID is assigned to it. Different activities of that user are attributable through NID. If user logged in again by another name then its activities can be compared. NID has the potential to track any intruder through no. of hosts.

## VII. Comparison of Different Distributed Intrusion Detection Systems

There are a lot of advantages and disadvantages of different distributed intrusion detection systems. Different distributed intrusion detection systems and there references are shown in table 1 and comparison of these systems is shown in table 2.

## VIII. Conclusion and Future Work

Only intrusion detection and prevention techniques are not sufficient for securing wireless network but there is also need of good Intrusion Detection System. From the existing DIDS anomaly based intrusion detection systems are more efficient and economic because of distributed nature of wireless ad hoc network. For better understanding of Distributed Intrusion Detection System

| Reference of IDS | Author | Algorithm | Merits | Demerits | ID Method |
|---|---|---|---|---|---|
| IDS1 | Kachirski and Guha | Mobile Agent Based. | Better network performance. | Only use anomaly based method. | Anomaly Based |
| IDS2 | Y. Huang | Cluster based Distributed Intrusion Detection scheme. | Improved efficiency in the terms of network overhead and memory usage. | False alarm rates are not mentioned and low performance. | Anomaly Based |
| IDS3 | R.Puttini | A Fully Distributed Algorithm. | Identify the source of packet dropping attack and suitable for MANET. | Very time consuming process to learn program profiles and testing processes. | Signature Based |
| IDS4 | R.Nakkeeran | Agent based Cooperative and Distributive system | Low false alarm rate and performance is better than other IDS. | No description about security issues of mobile agents. | Anomaly Based |
| IDS5 | Jelena Mirkovic | A Distributed System for DDoS Defense. | Ability to detect new attacks and latest misuse signatures. | Faces some challenges like arbitrary definition of abnormal activities. | Signature Based |
| IDS6 | James Carnady and Jay Harrell | Cluster based Intrusion Detection System | Reduces communication overheads and good detection rate. | More complex and ineffective co-ordination between DIDS modules. | Anomaly Based |

*Table 2 :* Comparison Table of different Distributed Intrusion Detection Systems (DIDS).

we have given details of different DIDS. We have also given comparison table of different DIDS according to their performance. Future work will involve developing more intelligent and robust intrusion detection algorithms. We will investigate number of attacks on Intrusion Detection System infrastructure.

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