

Detection of Attacks for Restoring Privacy of Users to Improve Mobile Collaborative Learning (MCL) Over Heterogeneous Network

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Abstract. The paper highlights the problems of rogue dynamic host configuration protocol (DHCP) server that affects and disrupts network resources during communication. The rogue DHCP is unauthorized server that releases incorrect IP address to legal users and sniffs their traffic illegally. The paper introduces multi-frame signature-cum anomaly-based intrusion detection systems (MSAIDS) supported with novel algorithms and addition of new rules in existing IDS. This innovative security mechanism reinforces the confidence of users, protects network from illicit intervention. The work is particularly done to restore the privacy of users over MCL but can be implemented with all types of small to large networks. Finally, the paper validates the idea through test bed simulation and compares the findings with other well-known existing techniques.

Keywords: Mobile collaborative learning, DHCP server, rogue DHCP server, signature-cum anomaly based Intrusion detection, sniffer.

1. Introduction

The rapid developments in information technologies (IT) have improvised the use of mobile devices in open, large scale and heterogeneous environments. The mobile devices build the bridge to connect users anytime and anywhere in the world. The deployment of mobile devices has not only underpinned communication but also created many chances for malicious attackers to crack the integrity and privacy of users. The mobile users are highly dependent on DHCP server for issuance of IP address because DHCP server provides highly organized service to mobile devices.

From other side, unauthorized DHCP server (rogue DHCP) creates the problems for users and breaks the security. It invites intruders and attackers to redirect and intercept network traffic of any device that uses the DHCP. Intruder modifies the original contents of communication. The malware and Trojans horse install rogue DHCP server automatically on network and affect the legitimate servers. If rogue DHCP server assigns an incorrect IP address faster than original DHCP server, it causes potentially black hole for users. To control the malicious attacks and avoiding the network blockage, the network administrators put their efforts to guarantee the components of server, using various tools. The graphical user interface (GUI) tool is used to prevent the attack of rogue detection [5]. Idea of using multilayer switches

may be configured to control the attacks of rogue DHCP server but it is little bit complex and not efficient to detect rogue DHCP server.

The DHCP spoofing is another solution for detecting rogue DHCP server. However, if single segment is spoofed that can damage the whole network. Spoofing method takes long time till intruder has enough time to capture the traffic and assign wrong IP address [8]. Time-tested, DHCP Find Roadkil.net's, DHCP Sentry, Dhcploc.exe and DHCP-probe provide the solution to detect and defend rogue DHCP server malware [6]. All of these tools cannot detect the new malicious attacks [2].

Distributed Intrusion Detection System (DIDS) is another technique to support the mobile agents. This technique helps the system to sense the intrusion from incoming and outgoing traffics to detect known attacks [1]. Ant colony optimization (ACO) based distributed intrusion detection system is introduced to detect intrusions in the distributed environments. It detects the visible activities of attackers and identifies the attack of false alarm rate but it does not detect DOS attacks [3]. Anomaly based intrusion detection are introduced to detect those attacks for which no signatures exist [4], [6], [10]. This paper introduces the multi-frame signature-cum anomaly based intrusion detection system supported with novel algorithms, inclusion of new rules in existing IDS to detect malicious attacks and increase the privacy and confidentiality of users. The reminder of paper is organized as follows: The section 2 describes related work and background study. Possible attacks of rogue DHCP server are explained in Section 3. The proposed solutions including functional components are given in section 4. Simulation setup is explained in section 5. The analysis of result and discussion are given in section 6. Finally conclusion of the paper is given in section 7.

2. Related Work and Background Study

The modern technologies and its deployment in computer and mobile devices have not only created new opportunities for better services but from other perspective, privacy of the users is highly questionable. The network-intruder and virus contagion extremely affect the computer systems and its counterparts. They also alter the top confidential data. Handling these issues and restoring the security of systems, IDS are introduced to control malicious attackers. IDS are erroneous and not providing the persistent solution in its current shape. The first contribution in the field of intrusion detection was deliberated by J.P Anderson in [7]. The author introduced notion about the security of computer systems and related threats. Initially, three attacks were discovered that are misfeasors, external penetrations and internal penetrations.

The classification of typical IDS is discussed in [17]. The focus of the contribution is about reviewing the agent-based IDS for mobile devices. They have stated problems and strength of each category of classification and suggested the methods to improve the performance of mobile agent for IDS design.

Four types of attacks are discussed in [21] for security of network. They have also simulated the behavior of these attacks by using simulation of ns2. A multi-ant colonies technique is proposed in [22] for clustering the data. It involves independent, parallel ant colonies and a queen ant agent. Authors state that each process for ant

colony takes dissimilar forms of ants at moving speed. They have generated various clustering results by using ant-based clustering algorithm. The findings show that outlier's lowest strategy for choosing the recent data set has the better performance. The contribution covers the clustering-based approach.

The work done in [18] is about the framework of distributed Intrusion Detection System that supports mobile agents. The focus of work is to sense both outside and inside network division. The mobile-agents control remote sniffer, data and known attacks. The paper has introduced data mining method for detection and data analysis. Dynamic Multi-Layer Signature based (DMSIDS) is proposed in [2]. It detects looming threats by using mobile agents. Authors have introduced small and well-organized multiple databases. The small signature-based databases are also updated at the same time regularly.

In addition, all of the proposed techniques cover general idea of network detection but proposed MSAIDS technique handles the irreplaceable issues of DHCP rogue server. The contribution also prevents almost all types of DOS attacks. The major contribution of work is to validate technique by employing innovative algorithms and inclusion of new rules in existing tradition. It also helps the legitimate users to start secure and reliable communication frequently over MCL. One of the most promising aspects of this research is uniqueness because there is no single contribution is available in survey about the DHCP rogue and its severe targeted attacks.

3. Possible Attacks of Rogue DHCP Server

The introduction of distributed system has highly affected the security [11]. There are several forms of vulnerabilities and vigorous threats to expose the security of systems. To take important security measures and enhancing the secure needs for organizations, several mechanisms are implemented but those mechanisms also invite attackers to play with privacy and confidentiality of users. One of the major threats for privacy of data is intervention of rogue DHCP server. The first sign of problem associated with rogue DHCP server is discontinuation of network service. The static and portable devices start experiencing due to network issues. The issues are started by assigning the wrong IP address to requested users to initiate the session.

The malicious attackers take the advantages of rogue DHCP server and sniff the traffic sent by legitimate users. Rogue DHCP server spreads wrong network parameters that create the bridge for intruders to expose the privacy. Trojans like DNS-changing installs the rogue DHCP server and pollutes network. Rogue DHCP server creates several problems to expose the privacy of legitimate users. We highlight two major types of security attacks to be created by rogue DHCP server.

3.1. Sniffing the Network Traffic

It is brutal irony in information security that the features which are used to protect static and portable devices to function in efficient and smooth manner; and from other side, same features maximize the chances for intruders to compromise and exploit the

same tools and networks. Hence packet sniffing is used to monitor network traffic to prevent the network from bottleneck and make an efficient data transmission. Intruders use same resources for collecting information for illegal use. Rogue DHCP server helps malicious intruders to expose privacy of users. When networks are victim of rogue DHCP server that provides very important information related to IP address, domain name system and default gateway to intruders.

All of this information helps intruders to sniff traffic of legitimate users. Rogue DHCP server is introduced on secure environment to collect confidential information and sniffs the traffic and wrecks the privacy of users shown in figure 1.

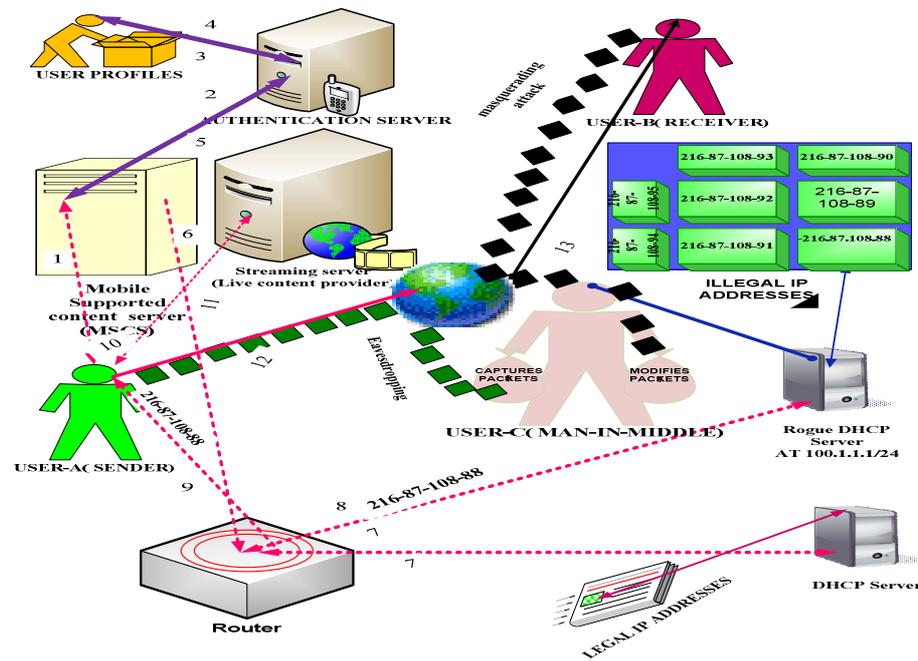


Figure 1. Sniffing the traffic and masquerading attack

Rogue DHCP server also facilitates for intruders to capture the MAC address of legitimate users. It causes sniffing the traffic through switch. In this case, intruder spoofs IP addresses of both sender and receiver and plays the man-of-middle to sniff traffic and extract important contents of communication. It causes the great attack on privacy of users.

3.2. Denial of Service Attack (DOS)

Intruder gets support through rogue DHCP server also uses DOS attacks after sniffing confidential contents of traffic. Due to DOS attack, the access of important services for legitimate users is blocked. Intruder often crashes routers, host, servers and other computer entity by sending overwhelming amount of traffic on the network. Rogue DHCP server creates friendly environment for intruder to launch DOS attacks because

intruder needs small effort for this kind of attack and it is also difficult to detect and attack back to intruder [12]. In addition, it is also easy to create floods on internet because it is comprised of limited resources including processing power, bandwidth and storage capabilities. Rogue DHCP makes flooding attack at domain name system (DNS) because target of intruder is to prevent the legitimate users [12] & [16]. These attacks on DNS have obtained varying success while disturbing resolution of names related to targeted zone. Rogue DHCP server takes advantages of inevitable human errors during installation, configuration and developing software. It creates several types of DOS attack documented in literature [20]. Intruder with support of Rogue DHCP server makes three types of attacks: fragile (smurf), SYN Flood and DNS DOS attacks shown in figure 2. These attacks are vulnerable and dangerous for security point of view.

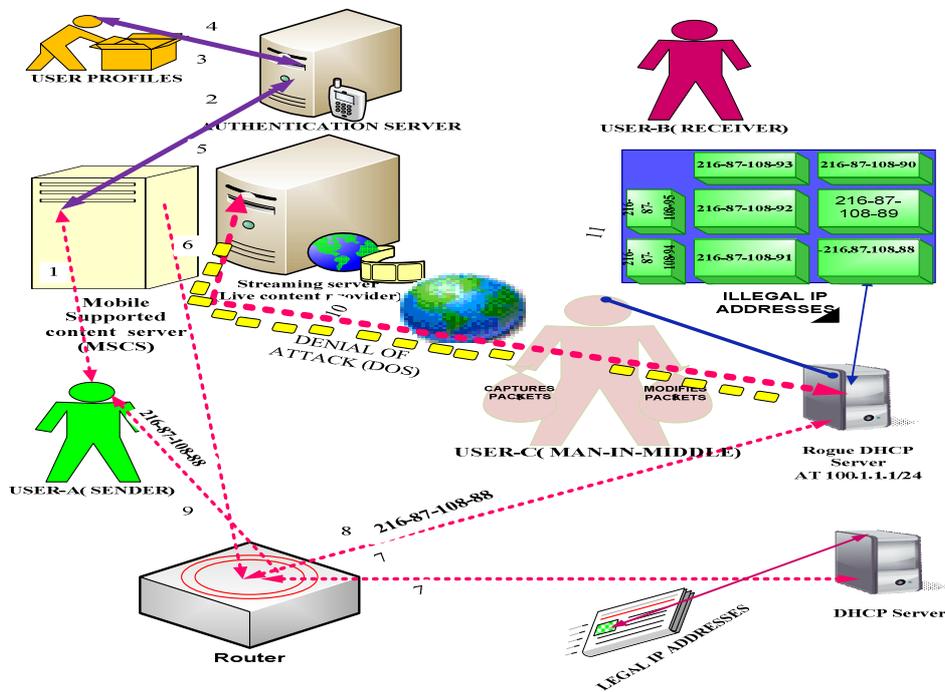


Figure 2. denial of service attack (DOS) attack

4. Proposed Solution (Multi-frame Signature-cum-anomaly based Intrusion detection system)

Networks are being converged rapidly and thousands of heterogeneous devices are connected. The devices integrated in large networks, communicate through several types of protocols and technologies. This large scale heterogeneous environment invites the intruders to expose security of users. Hence, IDS are

introduced to recognize the patterns of attacks, if they are not fixed strategically, many intruders cross IDS by traversing alternate route in network.

Many signature-based IDS are available to detect attacks but some of new attacks cannot be identified and controlled. Anomaly-based IDS is another option but it only detects limited new attacks. The multi-frame signature-cum anomaly-based intrusion detection system (MSAIDS) supported with algorithms is proposed to resolve issue of DHCP rogue. The proposed framework consists of detecting server that controls IDS and its related three units: (i) DHCP verifier unit (ii) signature database (iii) anomaly database.

During each detection process, intrusion detection starts matching from DHCP verifier, if any malicious activity is detected that stops process otherwise checks with two units until finds either malicious activity or not. Figure 3 shows MSAIDS.

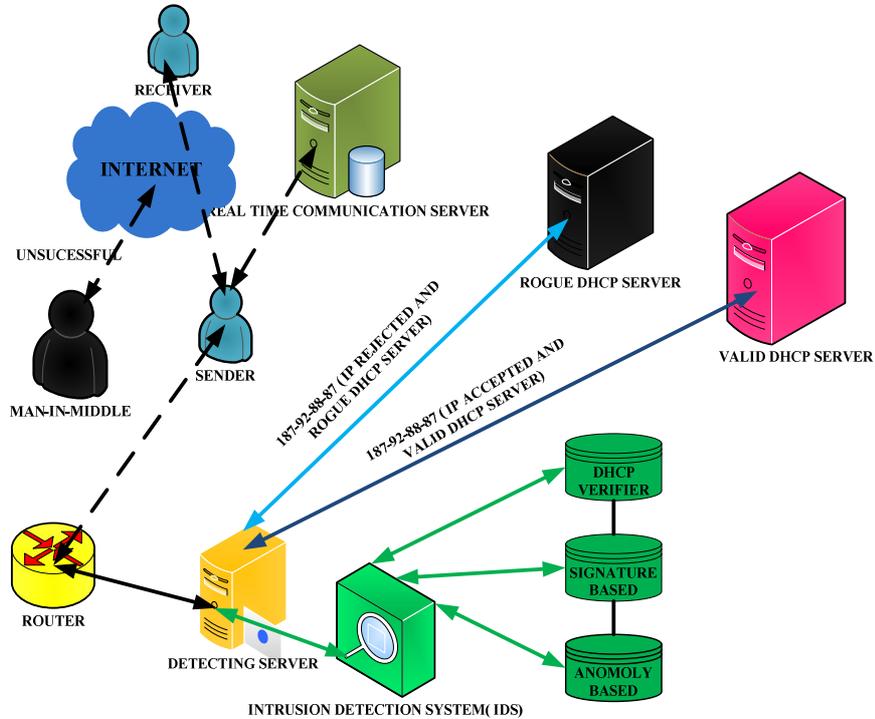


Figure 3. Multi-frame signature-cum-anomaly based IDS

The detecting server (DS) is responsible to check inbound and outbound traffic for issuance of IP address. The DS gets IP request (inbound traffic) from routers and forwards to DHCP server after satisfactory checkup. When any IP address is released for requested node then applies DHCP detecting algorithm for validation of DHCP server and detecting types of attack shown in algorithm 1.

Algorithm 1: Verify DHCP server and detecting the attack

1. Input: MF =(FD, FS,FA & I)
2. Output : For every strategy $I \in FA, I \in FS, D \in FD$

3. D = Each valid DHCP Server
4. IP= Internet protocol address
5. N= Number of mobile devices
6. FD= Frame DHCP server
7. If $D \in FD$
8. $IP \rightarrow N$
9. endif
10. S= Number of available signatures in signature based Intrusion detection system (SIDS)
11. FS= Frame of signatures
12. $FS \subseteq SIDS$
13. I= Number & Types of attacks
14. For (I=S; I ≤ FS; I++)
15. If $I \subseteq FS$
16. SIDS attack alert
17. endif
18. endfor
19. A= Number of signatures available in Anomaly based Intrusion detection system AIDS
20. FA= Frame of AIDS
21. $FA \subseteq AIDS$
22. For (I=A; I ≤ FA ; I++)
23. If $I \subseteq FA$
24. AIDS raises alert
25. If ($I \notin FS$ & $I \notin FA$)
26. No alert (No attack)
27. endif
28. endif
29. endfor

4.1. Monitoring Process of Detecting Server (DS)

The following rules collectively function to determine the anomalies.

- i. **Pre-selected rules:** They help to detect those patterns, which are already stored in DS that apply to identify the inbound traffic.
- ii. **Post-selected rules:** They refer to those patterns which are stored for detection of legitimate DHCP server that help to identify outbound traffic.
- iii. **Parameterized rules:** They refer to many ingredients that help to set selected rules with unique value presented in the following:
 - a. **Validity ingredient:** It helps to detect attack if intruder modifies the contents of message.
 - b. **Time interval ingredient:** It helps to detect two types of attacks which are exhaustion attack and negligence attack. In exhaustion attack, the intruder increases message-sending rate. In negligence attack, intruder does not send the message. In addition, time interval for two consecutive messages is increased or decreased than allowed amount of time that gives sign of attack.

- c. **Flooding ingredient:** It helps to identify attack on basis of noise and disturbance to be created in communication channel.
- d. **Retransmission ingredient:** It helps to determine attack, if retransmission does not occur before specified timeout period.
- e. **High transmission radio range ingredients:** It helps to determine SYN flood and wormhole attack, when intruder uses powerful radio sending message to further located node.
- f. **Pattern replication ingredient:** It helps to detect attack when same patterns are repeated several time, it blocks the DOS attacks.

All of these ingredients collectively help to DS for detecting the attacks and figure 4 shows the process how to determine valid IP address and attack.

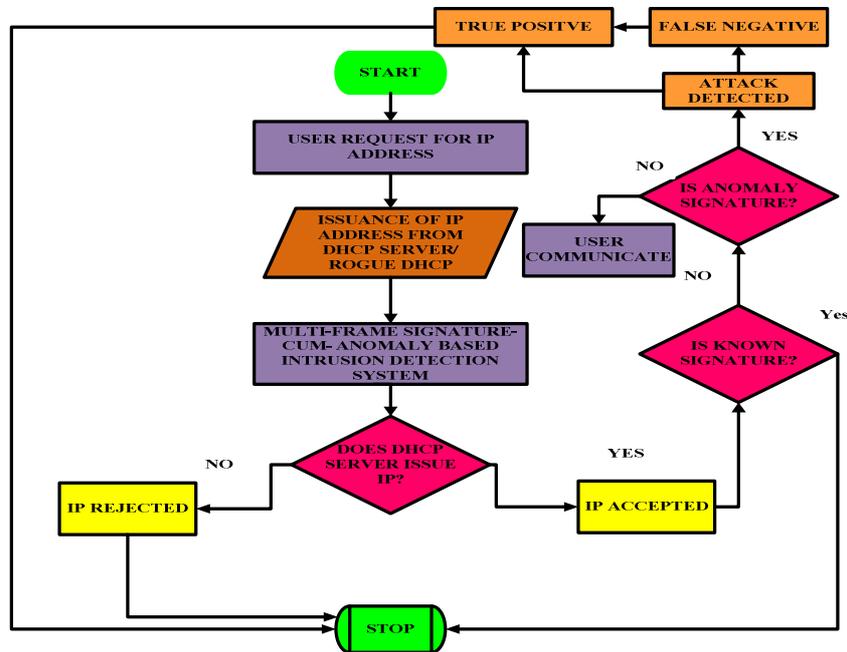


Figure 4. Detecting attack and issuance of safe IP

DS also controls the multi frame that comprises of central IDS and integrated with three layers that control the misuse detection.

4.2. Central IDS

The aim of central IDS is to control and store messages received from DS. It works as middleware for DS and other layers to send the verification request and receive alerts. The main function of central IDS is to update and manage the policy according to nature of attacks. If it needs any change in attack-detection that is employed on all the layers. The central IDS implements updated policy is shown in figure no 5.

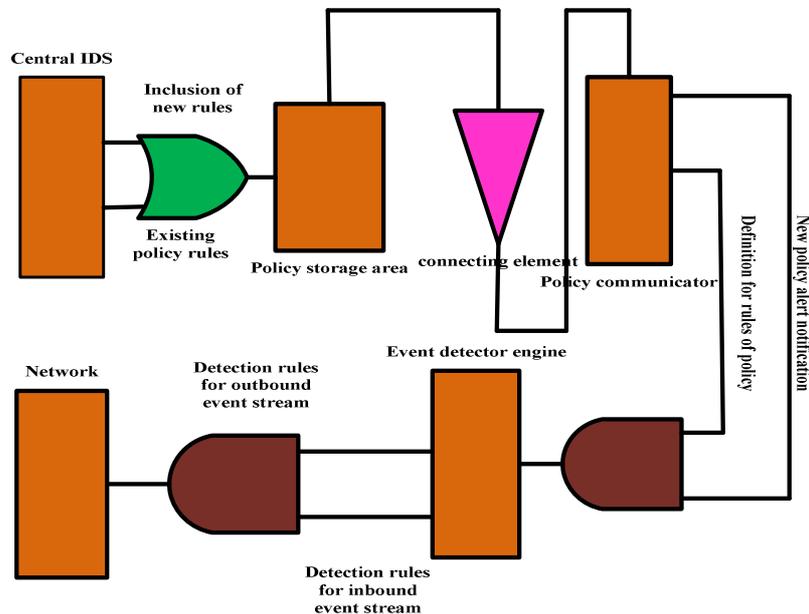


Figure 5. Policy of Central IDS for network

4.3. DHCP Verifier

DHCP verifier is top layer that distinguishes between rogue DHCP and original DHCP server. The signatures of original DHCP servers are stored at the DHCP verifier. It checks validity of DHCP server that issues IP address for client. On basis of stored signatures, DHCP server is identified whether it is rogue or original DHCP server. Top layer produces unique sign of alert for both DHCP rogue and original DHCP. Top layer receives parameters for verification from central IDS. DHCP verifier running on top layer is also responsible to return alert to central IDS.

4.4. Signature Based Detection Layer

Signature-based detection is middle layer that detects known threats. It compares signatures with observed events to determine possible attacks. Some known attacks are identified on basis of implemented security policy. For example, if telnet tries to use "root" username that is violating security policy of organization that is considered known attack. If operating system has 645 status code values that is sign of host's disabled auditing and refers as attack. If attachment is with file name "freepics.exe" that is alert of malware. Middle layer is effective for detection of known threats and using well-defined signature patterns of attack. The stored patterns are encoded in advance to match with network traffics to detect attack. This layer compares log entry with list of signatures by deploying string comparison operation. If signature based layer does not detect attack, anomaly based detection layer starts to process.

4.5. Anomaly Based Detection Layer

Lower layer is anomaly based detection that identifies unknown and DOS attacks. It works on pick-detect method. This method monitors inbound and outbound traffic

Packets are evaluated, adaptive thresholds and mean values are set. It calculates the metrics and compares with thresholds [19]. On basis of comparisons, it detects various types of anomalies including false positive, false negative, true positive and true negative. If pick-detect methods determines true positive and false negative then it sends alert to Central IDS. The process of detecting anomalies is given in algorithm 2.

Algorithm 2: Detecting the types of alerts with AIDS

1. FS= Frame of signatures
2. $FS \subseteq SIDS$
3. $S_i =$ False Negative
4. $S_j =$ True negative
5. $S_k =$ True positive
6. $S_l =$ False positive
7. 0 = don't match & 1= match
8. $S_{ijkl} = 1/d \sum_{m=1}^m S_{ijkl}$
9. $S_{ij} = \{ 0, \text{ if } i \& j$
10. No false negative & true positive
11. $S_{ij} = \{ 1, \text{ if } i \& j$
12. false negative & true positive
13. Alert of attack
14. $S_{kl} = \{ 0, \text{ if } k \& l [\text{ do not match}] \& 1, \text{ if } k \& l [\text{match}]$
15. Alert of true negative & false positive
16. No sign of attack
17. endif
18. endif
19. endif
20. endif

In addition to determine and calculate value of true positive and false negative; we apply algorithm 3 that helps to find attack and non-attack situation for TN and FN.

Algorithm 3: Determine the sign of attack or non-sign of attack

- I. We select random odd prime number for TN and any even number for FN.
2. The value of FN must not be exceeded than TN.
3. Therefore, $FN > 1 \& FN < TN$
4. Here, $FN = \{2, 4, 6, 8, \dots\}$ & $TN = \{3, 5, 7, 11, 13, \dots\}$
5. Here sign of attack = ST, d = not exposed & b = exposed.
6. b and d has constant value 1.
7. Thus, $ST = TN / (TN + d) / FN (FN + b)$
8. If value of $ST > 1$, it means there is no sign of attack, if the value of $ST < 1$ that is sign of attack.
9. endif

Assume $FN = 2$ & $TN = 3$: BY applying the sign of attack formula:

$ST = TN / (TN + d) / FN (FN + b)$: Substitute the values in given formula.

$$ST = 3 / (3 + 1) / 2(2 + 1)$$

ST = 9/8
 ST= 1.125
 ST > 1

Here, ST > 1 means there is no sign of attack and we will be able to determine that is True negative (TN).

5. Simulation Setup

The previous sections have presented evidence of problems to be created by rogue DHCP server and including solutions to control problems. This section focuses on simulation setup and type of scenario. To validate the approach, the proposed solution has been implemented by using three methods: test bed simulation, discrete simulation in C++ and ns2 simulation.

We discuss only test bed simulation in this paper that provides real time results in controlled and live user environments. This kind of simulation gives complete understanding about behavior of several types of attacks. All operations associated with MSAIDS approach and other three existing approaches: Dynamic Multi-Layer Signature based IDS (DMSIDS), Ant Colony Optimization based IDS (ACOIDS) & Signature based IDS provide the recital idea. The parameters of test bed simulation are only given in table 1.

Table 1. Simulation parameters for test bed experiment.

Name of parameters	Specification
MySQL database	MySQL 5.5
Type of IDS	Rule based IDS
GD Library	gd 2.0.28
Snort	V-2
Apache web server	Apache http 2.0.64 Released
PHP	PHP 5.3.8 (Server side language)
ADODB	Release 5.12 (abstraction library for PHP and Python)
ACID	ACID PRO 7
Stick	Stick beats detection tool used by hackers
Nikito	Nikito v.2.1.4
IDS enabled system	Memory: 512 MB
	Operating system: Linux

	PCI network card: 10/100 Mbps
	CPU: P-III with 600 MHz
Attacker system	Memory: 1.5 GB
	Operating system: Linux
	PCI network card: 10/100/1000 Mbps
	CPU: AMD Geode LX running 2.4/5GHz

In addition, most of operating systems do not provide the tracing facilities but regardless of problems, we would like to obtain result in standardized method by using different programs on different operating systems. MSAIDS has fully support of algorithms and data structure that discover potential attacks and perturb the intrusions before the attacks. The performance highly depends on robust tracing facility and algorithms, which help to identify the intrusion. The first step is to analyze performance of proposed algorithms. However, overall target is to obtain accurate statistical data in highly loaded network. Test bed simulation provides promising result. The mean value is calculated with help of following theorem.

Theorem 1:

Assume x = test bed simulation;

y = discrete simulation in C++ & ns2 simulation.

R is the proposed approach MASIDS.

Thus, Let $f: [x, y] \rightarrow R$ is the continuous function for closed interval $[x, y]$

Therefore

Let $f: [x, y] \rightarrow R$ is the differentiable continuous function for open interval (x, y)

Here $x < y$.

Hence z exists in (x, y)

Such that

$$f'(x) = \frac{f(x) - f(y)}{(x - y)}$$

6. Analysis of Result and Discussion

The training period of experiment covers four classes of attacks probe, DOS, U2R and R2L. All detected attacks are included in database during the training period in test bed simulation. The MSAIDS scans all rules of snort and includes new rules explained in proposed section 4. The testing period targets one concise scenario. The scenario is simulated by using same parameters for all three existing approaches including our proposed MSAIDS. The attacks are generated by using stick, covering all types of signatures and anomaly based attacks. The training period provides quite interesting results because frequently generated attacks are of different numbers. The maximum number of attacks pertains to R2L category. The more attacks are also counted on MSAIDS as compare with other three existing techniques are shown in table no.2. If attack is not generated then it is counted as normal traffic. The frequency of single and group characters are displayed when packets reach at the

intruder's machine. It is observed on the basis of output that different types of detected attacks are generated due to rogue DHCP server.

The DOS attacks are detected when packet does not reach at destination and received no acknowledgment. The sign of probe attack is addition of new data in existing amount of data bytes. U2R is the sign of maximum connection duration. R2L attacks are little bit complex to detect. We apply method comprises of service requested and duration of connection for network and attempts failed login for host. It shows that proposed approach does not restrict the generating ratio of packets. From other side, the proposed approaches provide highest capturing ratio. The statistical results show that MSAIDS will substantiate to medical field for diagnosing several disease and especially for heart. The major breakthrough of this research is to detect the true positive and false negative attacks because they are very hard to capture.

Table 2. Showing statistical data for attacks.

Types of attack	(MSAIDS)	(DMSIDS)	(ACOIDS)	Signature based IDS
DOS attacks	34214	33542	33421	32741
U2R attacks	12454	11874	11845	11341
R2L attacks	34123	32123	31092	29984
Probe attacks	6214	8758	10181	4907

The proposed method also captures real worm and all other looming attacks. Another advantage of MSAIDS is to detect all types of anomalies and unknown threats efficiently. It creates specific alarm for each type of anomalies. MSAIDS is robust and persist when attack is detected. Data shows 99.996% efficiency of MSAIDS shown in figure 6. The MSAIDS gives 2.269 to 49.11 higher efficiency than other techniques.

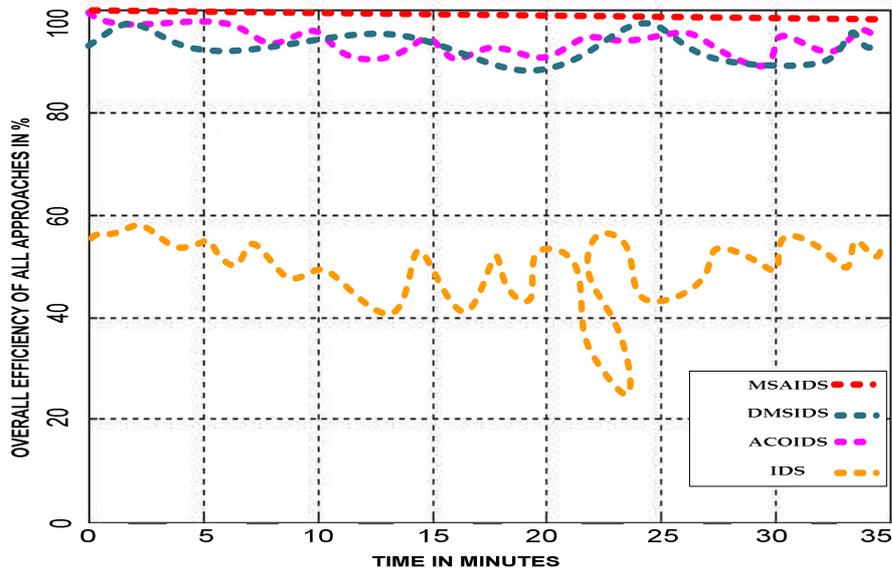


Figure 6. Comparison efficiency of all approaches

7. Conclusion and Future Works

In this paper, multi-frame signature-cum anomaly-based intrusion detection systems (MSAIDS) is presented. MSAIDS controls malicious activities of DHCP rogue server to restore the privacy of users. The paper highlights malicious threats to be generated by DHCP rogue. The intruders use DHCP server to sniff traffic and finally deteriorate confidential information. The mechanism of current IDS does not have enough capability to control several types of malicious threats. Furthermore, several daunting and thrilling challenges in the arena of computer network security are impediment for secure communication. DHCP rogue is visibly very simple but crashes network as well as privacy of the users and even creates nastier attacks like Sniffing network traffic, masquerading attack, shutting down systems and DOS. The first is detailed explanation of attacks and how to resolve this issue. Second, we propose technique that is based on algorithms and addition of new rules in existing current IDS. These all of the components of proposal collectively handle the issues of DHCP rogue.

To validate the proposal, the technique is simulated by using test bed. Two different kinds of systems are used in test bed; as one is reserved for intruder and other one is for legitimate user. On basis of simulation, we obtain very interesting data, which show that MSAIDS improves capturing performance and controls attacks to be generated by DHCP rogue as compare with original IDS and other well known techniques. The findings demonstrate that MSAIDS has significantly reduced false alarms. Finally, we analyze overall efficiency of MSAIDS and existing techniques. In future, this technique will be deployed to measure the heart beats and cancer.

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