NETWORK INTRUSION PREVENTION SYSTEM (NIPS) BASED ON NETWORK INTRUSION DETECTION SYSTEM (NIDS) AND ID3 ALGORITHM DECISION TREE CLASSIFIER

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Thesis submitted in fulfillment of the requirements
for the award of the degree of
Master of Science
(Computer)

Faculty of Computer Systems and Software Engineering
UNIVERSITI MALAYSIA PAHANG

MAY 2011

UNIVERSITI MALAYSIA PAHANG
CENTER FOR GRADUATE STUDIES

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Dedicated to my parents, my grand parents, my beloved wife, my children and my big family

ACKNOWLEDGMENTS

I would like to express my most sincere gratitude to the supervisory Dr. Noraziah Ahmad for his continuing support, professional guidance and for giving me an opportunity to learn what research is all about. Special gratitude also to Prof. Abdullah Embong, Mr. Mohamad Fadli Zolkipli and Mr. Mohamad Ramiza Ramli for their contributions, guidance and time towards this research.

Sincerely thanks should be forwarded to Naib Chancellor Universiti Malaysia Pahang (UMP) YH. Prof. Dato' Dr. Daing Mohamed Nasir bin Daing Ibrahim; DIMP, for the Grant Research Scheme. Not forget to Dean Faculty Computer Systems and Software Engineering (FSKKP), Assoc. Prof. Dr. Jasni binti Mohamad Zain; staffs in HR Departement and all friends in UMP.

Special gratitude also to my family, especially to my mother, Syamsiar; in memory of my father, Abdul Hadi; my beloved wife, Nerry Thirta Dewi; my child, Zahra Zahirah Muhammad and Arifah Azzura Muhammad; my brother Suhaili, Ramdhan and Muhammad Nasir; my sister Maharani; my mother in-law, Hj. Maharani Rahman, and my father in-law, H. Warnerry Robert, my brother in law, Roy Ferdinand Chandra; my sister in-law, Renny Andhora and Gusti Wulandari; for their patience and morale support. Not forget to big family of Syed Burhanuddin Zulkarnain and dr. Tengku Noraida Adlan are always helpful and supportive to me.

Finally, I thank to all my friends especially to Furqan, Sajadin, Handrizal, Rahmat, Triantoro, Fakhri, Triantoro and others who have contribute in this research.

ABSTRACT

Network security has gained significant attention in research and industrial communities. Due to the increasing threat of the network intrusion, firewalls have become important elements of the security policy. Firewall performance highly depends toward number of rules, because the large more rules the consequence makes downhill performance progressively. Firewall can be allow or deny access network packets incoming and outgoing into Local Area Network (LAN), but firewall can not detect intrusion. To distinguishing an intrusion network packet or normal is very difficult and takes a lot of time. An analyst must review all the network traffics previously. In this study, a new way to make the rules that can determine network packet is intrusion or normal automatically. These rules implemented into firewall as prevention, which if there is a network packet that match these rules then network packet will be dropped. This is called Network Intrusion Prevention System (NIPS). These rules are generated based on Network Intrusion Detection System (NIDS) and Iterative Dichotomiser 3 (ID3) Algorithm Decision Tree Classifier, which as data training is intrusion network packet and normal network packets from previous network traffics. The experiment is successful, which can generate the rules then implemented into a firewall and drop the intrusion network packet automatically. Moreover, this way can minimize number of rules in firewall.

ABSTRAK

Keselamatan rangkaian telah mendapat perhatian penting dalam penyelidikan dan masyarakat industri. Disebabkan peningkatan ancaman gangguan rangkaian, firewall telah menjadi elemen penting bagi polisi keselamatan. Kejayaan firewall sangat bergantung terhadap jumlah peraturan, kerana peraturan-peraturan yang lebih besar mengakibatkan prestasi semakin menurun. Firewall boleh membenar atau menolak paket akses rangkaian yang masuk dan keluar daripada Local Area Network (LAN), tetapi firewall tidak dapat mengesan intrusi. Untuk membezakan pakej intrusi rangkaian atau normal adalah sangat sukar dan memerlukan banyak masa. Seseorang penganalisis perlu memeriksa semua rangkaian trafik pada masa sebelumnya. Dalam kajian ini, suatu cara baru untuk membuat peraturan yang boleh menentukan pakej rangkaian intrusi atau normal secara automatik. Peraturan-peraturan ini diimplementasikan ke dalam firewall sebagai pencegahan, yang mana sekiranya ada pakej rangkaian yang sesuai dengan peraturan-peraturan ini pakej rangkaian akan diabaikan. Ini disebut dengan Network Intrusion Prevention System (NIPS). Peraturan-peraturan ini dijanakan berdasarkan Network Intrusion Detection System (NIDS) dan Iteratif Dichotomiser 3 (ID3) Algorithm Decision Tree Classifier, yang mana data latihan adalah intrusi pakej rangkaian dan normal pakej rangkaian daripada lalu lintas rangkaian terdahulu. Eksperimen ini telah berjaya, yang dapat menghasilkan peraturan-peraturan yang diimplementasikan ke dalam firewall dan pakej intrusi rangkaian diabaikan secara automatik. Selain itu, cara ini dapat meminimumkan jumlah peraturan dalam firewall.

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LIST OF SYMBOLS

$E(S)$	Entropy of S
$E(S,A)$	Entropy S of A
$Gain(S,A)$	Gain S of A
p_+	Categorized as positive
p_-	Categorized as negative

LIST OF ABBREVIATIONS

ACL	Access Control List
BIND	Berkeley Internet Name Domain
DARPA	Defense Advanced Research Project Agency
DHCP	Dynamic Host Configuration Protocol
DNS	Domain Name System
DoS	Denial-of-Services
FTP	File Transfer Protocol
GA	Genetic Algorithm
HIDS	Host Intrusion Detection System
ICMP	Internet Control Message Protocol
ID3	Iterative Dichotomiser 3
IDS	Intrusion Detection System
IP	Internet Protocol
IPS	Intrusion Prevention System
KDD	Knowledge Discovery in Database
LAN	Local Area Network
MAC	Media Access Control
NAT	Network Address Translation
NIPS	Network Intrusion Prevention System
NIDS	Network Intrusion Detection System
OS	Operating System
OSI	Open System Interconnection
R2L	Remote-to-Local

SNMP	Simple Network Management Protocol
SSH	Secure Shell
SVM	Support Vector Machine
SYN	Synchronize
TCP/IP	Transmission Control Protocol / Internet Protocol
U2R	User-to-Root
UDP	User Datagram Protocol
WAN	Wide Area Network

CHAPTER 1

INTRODUCTION

Several research articles have been published regarding firewall as prevention. Among them were those by Gollman D. (2006), Al-Shaer E.S. and Hamed H.H. (2004), Golnabi K. et al. (2006), Terpstra J.H. et al. (2004), Joko Y. and Onno W.P. (2008), Benelbahri M.A. and Bouhoula A. (2007), Tibbs R.W. and Oakes E.B. (2006), Winding R. et al. (2006), Suehring S. and Ziegler R.L. (2006), Katić T. and Pale P. (2007), Wenhui C. et al. (2006). Those articles revealed that updating firewall policy rules one of the current issues that still unsolved problems, where one of the problem is how to denied network packet intrusion (Gollman D., 2006; Al-Shaer E.S. and Hamed H.H., 2004; Golnabi K. et al., 2006; Tibbs R.W. and Oakes E.B., 2006; Suehring S. and Ziegler R.L., 2006 and Katić T. and Pale P., 2007). This is because several problems hinder in finding and creating the effective firewall rules of intrusion. Therefore, the study on this basis is initiated.

Development of the internet and the availability of tools for intrusion by hackers become critical component of network administration. An intrusion can be defined as actions that threaten the integrity, confidentiality or availability of a network resources (SANS Institute, 2008), such as user account, file system, system kernels and so on (Chandrasekar A. et al., 2009 and SANS Institute, 2008.)

Network security system is described by a firewall (Gollmann D., 2006; Al-Shaer E.S. and Hamed H.H., 2004, 2004; Guan X. and Yun-jie L, 2010; Golnabi K. et al., 2006; Tibbs R.W. and Oakes E.B., 2006; Suehring S. and Ziegler R.L., 2006; Katić T. and Pale P., 2007). Firewalls can limit certain network packet, but firewall cannot recognize that is network packet is an intrusion or attack. Conversely, there is no

Intrusion Detection System (IDS) software who can be immediately implemented into the firewall policy rules. IDS software can only generate an alarm or log such as *snort*, *honeypot* and *portsentry*.

1.1 NETWORK SECURITY AND INTRUSION DETECTION

Network Security arise from local computer network connected to wide-area network such as internet. During local network computer not connected to wide-area network, problem of network security is not be important. Network security explains the possibilities to arise from connected local network computer to wide-area network (Joko Y. and Onno W.P., 2008). The global internet connection, network security has gained significant attention in research and industrial communities. Due to the increasing threat of network attacks, firewalls have become important elements of the security policy is generally (Al-Shaer E.S. and Hamed H.H., 2004; Benelbahri M.A. and Bouhoula A., 2007 and Suehring S. and Ziegler R.L., 2006).

Firewall is network security and first line of defense against external network attacks and threats. Firewall controls or governs network access by allowing, denying or forward the incoming and outgoing network traffics (Guan X. and Yun-jie L., 2010; Golnabi K. et al., 2006; PC Perspective, 2008; Tibbs R.W. and Oakes E.B., 2006; Suehring S. and Ziegler R.L., 2006; Mitra S. and Acharya T., 2003; Katić T. and Pale P., 2007 and Yan Y., 2010).

Firewalls can protect network systems and minimize the risk of attacks to the network. Intrusion Detection System (IDS) is good for detecting the existence of intrusion. The technology is joining ability of IDS and protection, so-called Intrusion Prevention System (IPS) (Wiliam W.S.C., 2005). IPS can detect intrusion and then drop of intrusion as prevention. Intrusion prevention is an evolution of intrusion detection.

1.2 PROBLEM STATEMENT

Behavior of intrusion conducts an attack is slowly, continuous and requires a long time. They made preparations to find all information of the system, such as machine and operating system (OS) used, ports, administrator, software application used, network topology and so on. Intrusion learn from the system and perform an attack that no longer generate an alarm (Gollmann D., 2006). All of activities can be seen on network traffic logs. Log can provide a useful information and crucial to be able to distinguish normal activities and intrusive activities (Terpstra J.H. et al., 2004).

Network traffics can be observed from log files (Golnabi K. et al., 2006) as human pattern recognize (Winding R. et al., 2006). For illustration, in Table 1.1 there are 15 records network traffic which consists 10 intrusion network pakckets and 5 normal network packet. All the network packet of intrusion should be dropped into firewall rules for network security. In Figure 1.1 shows intrusion network packet in Table 1.1 that was implemented into firewall rules.

Table 1.1 Network traffics illustration

No	Source IP	Dest IP	Dest Port	Protocol	Intrusion
1	122.206.13.100	10.10.1.2	22	TCP	Yes
2	122.306.13.100	10.10.1.2	22	TCP	Yes
3	122.306.13.100	10.10.1.2	22	TCP	Yes
4	122.306.13.100	10.10.1.5	22	TCP	Yes
5	122.306.13.100	10.10.1.5	80	TCP	Yes
6	122.306.13.100	10.10.1.3	80	TCP	Yes
7	203.130.14.20	10.10.1.5	22	TCP	No
8	203.130.14.20	10.10.1.5	22	TCP	No
9	203.130.14.20	10.10.1.3	22	TCP	No
10	203.130.14.20	10.10.1.3	80	TCP	Yes
11	206.145.206.4	10.10.1.2	21	TCP	Yes
12	206.145.206.4	10.10.1.2	80	TCP	Yes
13	206.145.206.4	10.10.1.3	80	TCP	No
14	206.145.206.4	10.10.1.5	80	TCP	Yes
15	206.145.206.4	10.10.1.5	80	TCP	No

```
R1   :  -A FORWARD -p tcp -s 122.206.13.100 –sport 1360  -d 10.10.1.2 --dport 22 -j DROP
R2   :  -A FORWARD -p tcp -s 122.206.13.100 –sport 1425 -d 10.10.1.2 --dport 22 -j DROP
R3   :  -A FORWARD -p tcp -s 122.206.13.100 –sport 1488 -d 10.10.1.2 --dport 22 -j DROP
R4   :  -A FORWARD -p tcp -s 122.206.13.100 –sport 1559 -d 10.10.1.5 --dport 22 -j DROP
R5   :  -A FORWARD -p tcp -s 122.206.13.100 –sport 1620 -d 10.10.1.5 --dport 80 -j DROP
R6   :  -A FORWARD -p tcp -s 122.206.13.100 –sport 136 -d 10.10.1.3 --dport 22 -j DROP
R7   :  -A FORWARD -p tcp -s 203.130.14.20 –sport 4607-d 10.10.1.3 --dport 80 -j DROP
R8   :  -A FORWARD -p tcp -s 206.145.206.4 –sport 4690 -d 10.10.1.2 --dport 21 -j DROP
R9   :  -A FORWARD -p tcp -s 206.145.206.4 –sport 1552 -d 10.10.1.2 --dport 80 -j DROP
R10 :  -A FORWARD -p tcp -s 206.145.206.4 –sport 1330 -d 10.10.1.5 --dport 80 -j DROP
```

Figure 1.1 Firewall rules drop the intrusion network packet

Packet filtering firewall can limit the access to the connection base on parameters including protocol, source IP, destination IP, source port, destination port etc (Al-Shaer E.S. and Hamed H.H., 2004; Golnabi K. et al., 2006; Tibbs R.W. and Oakes E.B., 2006; Suehring S. and Ziegler R.L., 2006 and Katić T. and Pale P. , 2007). Packet filtering firewall has the character of the static thus function also static and has limitation (Suehring S. and Ziegler R.L., 2006 and Wiliam W.S.C., 2005). For example, access to the web server using port 80 allowed by the firewall policy rule, so from anywhere activities pass port 80 is allowed although there is attempt penetration by intruder. Therefore, these rules are in a constant need of updating by inserting, modifying or removing, tuning and validating (Al-Shaer E.S. and Hamed H.H., 2004; Golnabi K. et al., 2006; Suehring S. and Ziegler R.L., 2006 and Katić T. and Pale P. , 2007).

If every intrusion will be implemented to firewall rules which not carefully ordered and selective, this condition will makes the policy contains a large number of firewall rules. The possibility of policy anomaly will be happened relatively high, such as writing conflicting or redundant rules (Al-Shaer E.S. and Hamed H.H., 2004). This condition causes the performance of firewall decreases (Gollmann D., 2006; Dunham and Margareth H., 2002 and Benelbahri M.A. and Bouhoula A., 2007), because incoming and outgoing every network packet must be checked against the rules until the rules found matching (Gollmann D., 2006; Golnabi K. et al. 2006 and Khalil R.K. et al., 2010).

The distinguishing an intrusion network packet manually through log files is difficult, because requiring a lot of time and tedious (Al-Shaer E.S. and Hamed H.H., 2004 and Golnabi K. et al., 2006). An analyst must review all of network traffic. For example in Table 1.1, that describe line 11, 12, 13, 14 and 15 with same source IP 206.145.206.4 were have two categories: intrusion activities and normal activities. It is required a method to create intrusion rules that be able to select a IP address which have two categories. Therefore, the necessary means to selectively and automatically determining a network packet is an intrusion that called NIDS and then to implemented into firewall rules as prevention. Combination both of NIDS and firewall namely NIPS.

The task of manually-manage firewall policy rules becomes very difficult and takes a lot of time, because the number of network traffics are increase and continuous. This huge task which requires a way to automatically update the firewall rules (Golnabi K. et al., 2006).

1.3 OBJECTIVES OF THE RESEARCH

The objectives of the research are as follows:

i. To propose a new framework of Network Intrusion Prevention System (NIPS) based on Network Intrusion Detection System (NIDS) and ID3 Algorithm Decision Tree Classifier.
ii. To implement and analyse the performance of the framework in the computer network environment.

1.4 OVERVIEW OF THE THESIS

The distinguish network traffics is intrusion or normal is very difficult and takes a lot of time. An analyst must review all the data of network traffics to find the intrusion then implemented into firewall rules as prevention.

This research makes rules that can determine network packet is intrusion, then rules are implemented into the firewall as NIPS. Rules resulting from the construct decision tree using ID3 algorithm and network packets as data training. Network packet obtained from the log files that record the activity of network traffics. Network packet intrusion and normal as data training extracted into five attributes: source IP address, destination IP address, source port, destination port and protocol. To determine the packet is a network intrusion or a normal use the *Snort* NIDS software. *Snort* also generate log files and parse log files that perform intrusion and normal.

1.4 ORGANIZATION OF THE THESIS

This thesis is organized as follows: Chapter 2 reviews the Intruder, Intrusion Detection System (IDS), Intrusion Prevention System (IPS), Log Files, Firewall, Data Mining and Decision Tree Classifier of Data Mining. Chapter 3, proposes NIPS based on NIDS and ID3 algorithm decision tree classifier. Chapter 4, the implementation and analysis the performance rules in computer network environment. Finally, the Conclusion and Recommendations are presented in Chapter 5.

1.5 CONCLUSION

This chapter explains network security that gained significant attention in computer network. To distinguish the intrusion activities from normal activities of the network traffics is very difficult and require a lot of time. It is needed a method to define intrusion from network traffics automatically that called NIDS. Firewall able to protect network system and can minimization risk of intrusion. NIDS and firewall have become important element of the network security. In addition NIDS can detect existence network intrusion. Combination both of NIDS and firewall namely NIPS can detect and deny existence of intrusion. Meanwhile, network security the highly performance depends of the firewall policy rules (Tibbs R.W. and Oakes E.B., 2006 and Suehring S. and Ziegler R.L., 2006). To generate and managing firewall policy rules require a lot of time. An analyst must review all the data of network traffics previously. Therefore it is needed a process of creating firewall rules that reflect the previous network traffics.

CHAPTER 2

LITERATURE REVIEW

This chapter explains the basic concepts and related work that is part of the methodology**.** The basic concept are Intruder, Intrusion Detection System (IDS), Intrusion Prevention System (IPS), Log Files, Firewall and ID3 Algorithm Decision Tree Classifier. All of the concept and related work are presented in this chapter.

2.1 INTRUDER

There are many alternatives to perform intrusion. The intruder will find all information about the target computer system and take advantage of the weaknesses of computer systems. Intrusion can be prevented by always update the system and issues of computer network security (Rafiudin R., 2002).

There are four main categories of intrusion, which are denial-of-service (DoS), probe, user-to-root (U2R) and remote-to-local (R2L) (Khoi-Nguyen T. and Huidong J., 2010; Theodiridis S., 2006 and Ye Q. et al., 2010). Each of these categories represents the generalization of specific attack types. These main categories represent the classification of types of behaviors that can be grouped logically together. For each category, there are multiple attack types and unique to a particular pattern. Table 2.1 shows categories and types of intruder.

Table 2.1 Categories and examples of intruder

CATEGORY	EXAMPLES
DoS	apache2, back, land, mailbomb, Neptune, pod, processtable, smurf, teardrop, upstorm
probe	portsweep, ipsweep, nmap, mscan, saint, satan
U2R	buffer_overflow, httptunnel, loadmodule, perl, ps, rootkit, sqlattack, xterm
R2L	spy, ftp_write, guess_passwd, imap, multihop, named, phf, sendmail, snmpgetattack, snmpguess, warezclient, warezmaster, worm, xlock, xsnoop

2.1.1 Denial-of-Service (DoS)

Denial-of-Service (DoS) attacks is generally known by its attempts to interrupt a service provided as a part of a network (Chandrasekar A. et al., 2009; Dong S.K. et al., 2005; Firewall is it Needed, 2008; Guan X. and Yun-jie L., 2010 and Khoi-Nguyen T. and Huidong J., 2010). An example of a DoS attack is when a service is flooded with requests that it cannot respond effectively "denying" service to any request. The Transport Control Protocol (TCP) with flag SYN (synchronize/start) flood attack is type of attack, wherein SYN connection requests are made that never closed. DoS attacks have crippled websites for extended periods of time. Some have even taken down large portions of the internet, due to the traffic bottlenecks created.

2.1.2 Probe

Probe are the searches for network vulnerabilities to be used in other attacks (Chandrasekar A. et al., 2009; Dong S.K. et al., 2005 and Guan X. and Yun-jie L., 2010). Typically, a network scanned to find servers, and the servers are then scanned for open ports or known vulnerabilities. The signatures of these attacks are usually easy to identify, due to their searching nature. The danger which they impose is their ability to find vulnerabilities that can be leveraged in another attack. The difficulty in network security is the balance between usability and security. If all resources are tightly restricted, then users are limited in the features or applications they can access. If the security is loose then it become vulnerable toward attacked. Most networks tend to be loose in their security practices. This is why probes are a successful form of intrusion and pose a threat to security.

One example of a probe attack is a “port scan”. This attack uses the approach of incrementally making request to service port on a system. It verifies whether a known service is running on that port, and it learns the attributes of the service. With this knowledge, a more threatening attack can be formed that advantage of vulnerabilities in poorly secured services.

2.1.3 User-to-Root (U2R)

This attack where an intruder exploitation began in systems with normal user account and attempts to abuse the vulnerability in the system to get super user privileged. U2R attack can be the most damaging to system integrity. A U2R attack consists of a user with normal access privileges counterfeiting root level access and full control over the system. Most of these intrusions with buffer overflows in the operating systems that allow a user to gain root access. With root access, the intruder has complete access and control over the machine. Integrity of data and information can be lost or damaged. If intruders gain access to the system as root, it has a greater ability to hide from the intrusion detection.

2.1.4 Remote-to-Local (R2L)

A remote-to-local (R2L) attack allows a remote, non-authorized user to simulate local user privileges on machine (Chandrasekar A. et al., 2009; Dong S.K. et al., 2005 and Guan X. and Yun-jie L., 2010). There are different approaches, including: dictionary-based password and username guessing, attacking vulnerabilities or bugs, and attacking poorly the configured services. Some of these attacks, such as dictionary attacks, are more easily detected than others. As an authorized user on the machine, the intruder can gain the access to private information, disrupt certain services, can corrupt data, or install applications that allow him or her to gain the control of services that can be used for other malicious behavior. This type of attack can lead to security breaches that allow complete access and control of the machine (user-to-root).

2.2. INTRUSION DETECTION SYSTEM (IDS)

Intrusion detection is detecting actions that attempt to compromise the confidentiality, integrity or availability of resources (Gollman D., 2006; Duanyang Z. et al. 2010; SANS Institute, 2008; Shingo M. et al., 2010 and Weenke L., 2001). When Intrusion detection takes a preventive measure without direct human intervention, then it becomes an Intrusion Prevention System.

Intrusion detection can be performed manually or automatically. Manual intrusion detection is examining log files and then determine network packet is intrusion or not. A system that performs automated intrusion detection is called an Intrusion Detection System (IDS) (Kenneth G.J., 2005; Rafiudin R., 2002 and Winding R., 2006).

Intrusion Detection System the operating systems that allow a user to gain root access. With root access, the intruder has complete access and control over the machine, system is very important in network security. Meanwhile, computer networks continue to expand. IDS need to be able to deal with a large computer network. Therefore, automatic procedures for detecting and responding to intrusion are becoming increasingly essential (Mehmed M.K. and Jozef Z., 2005).

Misuse detection searches for patterns user behavior that match intrusion, which are stored as signatures. These hand-coded of signature are laboriously provided by human experts based on their knowledge of intrusion techniques. If a pattern match is found, then the alarm will appear as a sign. Human security analysts evaluate the alarms to decide what action to take, whether it is shutting down part of the system, alerting the internet service provider about suspicious traffic. An intrusion detection system for a large complex network may produce thousands or millions of alarms per day. Because systems are not static, the signatures need to be updated whenever new software versions arrive or changes in network configuration (Al-Shaer E.S. and Hamed H.H., 2004). There are two main types of IDS pursuant where data analyzed, which describe in sub chapter 2.2.1 and 2.2.2.

2.2.1 Network-based IDS

Network Intrusion Detection System (NIDS) is an attack of signatures in network traffic. Typically, a network adapter running to monitors and analyzes all network traffic in real time. NIDS is an independent platform that identifies intrusions by examining network traffic and monitors multiple hosts. NIDS gains access to network traffic by connecting to a hub or network switch. An example of a NIDS is software namely *snort* (Gollman D., 2006; Flior E. et al., 2010 and SANS Institute, 2008).

2.2.2 Host-based IDS

Host Intrusion Detection System (HIDS) looks for attack signatures in log files of hosts (Duanyang Z., 2010 and Gollman D., 2006). HIDS are attempts to identify unauthorized and anomalous behavior on a specific device. HIDS generally involves an agent installed on system, monitoring and alerting on local OS and application activity. The installed agent uses a combination of signatures, rules, and heuristics to identify unauthorized activity. The role of a host IDS is passive, only gathering, identifying, logging and alerting of intrusion (SANS Institute, 2008).

There are other ways of finding intrusion attempts. One alternative method is to load software to look for signs of intrusion on the system itself. If a machine has been exploited, often certain system files will be altered. For examples, the password file may be changed, users may be added, system configuration file may be modified, or file permissions might be altered. By looking at changes in these files, there is an intrusion or other unusual activity. There are two classification IDS pursuant how data analyzed, which describe in sub chapter 2.2.3 and 2.2.4.

2.2.3 Misuse Detection

In misuse detection, the IDS analyzed the information it gathered and compare it with large databases of attack signatures. Essentially, the IDS are looks for a specific attack that has already been documented. Learning system from the existing pattern of attack and recognized. This method unable to detect the new attack is which its pattern not yet been known (Duanyang Z., 2010).

2.2.4 Anomaly Detection

In anomaly detection, the system administrator defines the baseline, or normal, state of the network's traffic load, breakdown, protocol, and typical packet size. The anomaly detector monitors network packets to compare their state to the normal baseline and looking for anomalies.

Statistical anomaly detection uses statistical techniques to detect potential intrusions. During operation, a statistical analysis of the data monitored is performed and the deviation from the baseline is measured. If a threshold is exceeded, an alarm is issued. On the other hand, anomaly detection detects just anomalies. Suspicious behavior does not necessarily constitute an intrusion (Gollman D., 2006).

2.2.5 IDS Products

Many IDS systems exist and a lot of confusion because there is little in the way of standards with how they operate. It is difficult to provide a direct comparison between products because terminology, features and functionality. This is because there is no effective comparison can occur. Example of IDS product include *Snort*, *Honeypot* and *Portsentry*.

a. ***Snort***

Snort is open source NIDS (Yan Y., 2010). *Snort* capable of performing real-time traffic analysis and packet logging on computer networks. It can perform protocol analysis, searching/matching and can be used to detect a variety of attacks and probes, such as buffer over-flows, stealth port scans, CGI attacks, SMB probes, OS fingerprinting and much mores (Yan Y., 2010).

Snort uses a flexible rules language to describe traffic that it should collect or pass, as well as a detection engine that utilizes a modular plugin architecture. *Snort* has a real-time alerting capability as well, incorporating alerting mechanisms for *syslog* or a specific file user. *Snort* has three primary uses (Yan Y., 2010):

- **Sniffer mode** – to see the packet through the network.
- **Packet logger mode** – for recording all the packet through the network to the analysis at a later.
- **NIDS mode –** *snort* used to detect of attack carried out through computer networks. This mode required NIDS setup of rules that distinguish between normal packets or attack packets.

b. *Honeypot*

Honeypot only provide the security vulnerability of a system, thus providing space for attacked. *Honeypot* is to trap intruder to penetrate computer system. When there are attacks, *honeypot* will be recorded in the log files so the admin can do the next action. *Honeypot* is passive in that they are waiting for someone to attack.

c. *Portsentry*

Portsentry is a software designed to detect port scanning and response actively if any port scanning. The port scanning is a scanning process of services variety applications running on computer servers. Port scanning is the first step before an attack will be undertaken. If there is a machine scan port to servers will actively block the attacker machine.

Portsentry will react in real time by blocking the IP address of the attacker. This was done by using *ipchains* or *ipfwadm* and insert into the file `/etc/host.deny` automatically by the TCP Wrapper. *Portsentry* reports through log files in `/etc/syslog`. The report indicates the system name, time attack, the attacker IP machine IP, protocol, and others. *Snort* and *portsentry* have different action where prevent intrusion, whereas *snort* is only detects the intrusion.

IDS produce has a different way of working and has a different way of prevention. Table 2.2 shows the comparison of work and prevention between *Snort*, *Honeypot* and *Portsentry*.

Table 2.2 Comparison IDS products

IDS Product	Work	Prevention
Snort	Intrusion network packet is known based on the rules. When a network packet has a similarity with a rule, then network packet is the intrusion. New attack has a new signature so that rules should always be updated	✔ generate log ✔ passive
Honeypot	Provide the security vulnerability of a system. When there are attacks, *honeypot* will be recorded in the log files.	✔ generate log ✔ passive
Portsentry	Detect machine who is doing port scanning	✔ generate log ✔ active ✔ blocking IP address of intrusion into file /etc/host.deny

2.3 INTRUSION PREVENTION SYSTEM (IPS)

Intrusion Prevention System prevent from intrusion or attacks. IPS work with an IDS, and vendors have combined the two technologies to make an IPS-capable IDS. Two techniques are used to prevent an attack (Rafiudin R., 2002) :

- **Sniping** – Allow the IDS to terminate a suspected attack from through the use of a TCP reset packet or ICMP unreachable message.
- **Shunning** – Allow the IDS to automatically configure router or firewall to deny traffic based on what it has detected and therefore shunning the connection. As IDS become more advanced, this shunning is evolving into a new term, blocking, where an IDS contacts a router or firewall and creates an access control list (ACL) to block the attacking IP.

The IDS can handle sniping. However, shunning requires the assistance of other device. IDS sensors should report back to a central console that, in turn also generates some responses if so configured. Following are some actions that an IDS generate in repose to an attack (Rafiudin R., 2002):

- **Reconfigure firewall/router** – An IDS with a shun enable configure the firewall to filter out the intruders IP address.
- **Send an SNMP trap** – Configure the IDS to send an SNMP trap datagram to a management console.
- **Generate log** – An IDS can log to Windows event log, Syslog server, pager or even send an e-mail.

2.4 LOG FILES

Log files are another critical facet in total security architecture. It is important to create a policy and strategy for dealing system and application. Log files are useful for three reasons (John H.T., et al., 2004):

1. Log files help with troubleshooting system problems and understanding what is happening on the system.
2. Logs serve as an early warning for both system and security events.
3. Logs can be indispensable in reconstructing events, whether determine an intrusion has occurred and are performing the follow-up forensic investigation.

Following some examples from *Snort* log files are shown Figure 2.1

```
[**] INFO - Possible Squid Scan [**]
04/20-14:06:49.953376 192.168.0.33:1040 -> 192.168.0.1:3128
TCP TTL:128 TOS:0x0 ID:393 IpLen:20 DgmLen:48 DF
******S* Seq: 0x60591B9  Ack: 0x0  Win: 0x4000  TcpLen: 28
TCP Options (4) => MSS: 1460 NOP NOP SackOK
```

Figure 2.1 *Snort* log file

From Figure 2.1, there is effort for the scan of existence of Squid proxy server IP address 192.168.0.1 and port 3128 from workstation IP address 192.168.0.33, port 1040 and protocol is TCP.

```
Feb 17 21:02:13 (none) sshd[14938]: Failed password for albi
from 172.18.64.26 port 3419 ssh2
```

Figure 2.2 *Syslog* log files

From Figure 2.2, someone tries to log in using the 'failed password' from IP address 172.18.64.26 and port 3419 passing ssh service using TCP protocol.

2.5 FIREWALL

A firewall is placed between two or more networks, usually a private network and public networks. Typical examples are the internet which is a zone with no trust and an internal network which is a zone of higher trust must be protected. The term firewall comes from the fact that by segmenting a network into different physical subnetworks, they limited the damage that could spread from one subnet to another just like firedoors or firewalls. Figure 2.3 shows firewall in computer network.

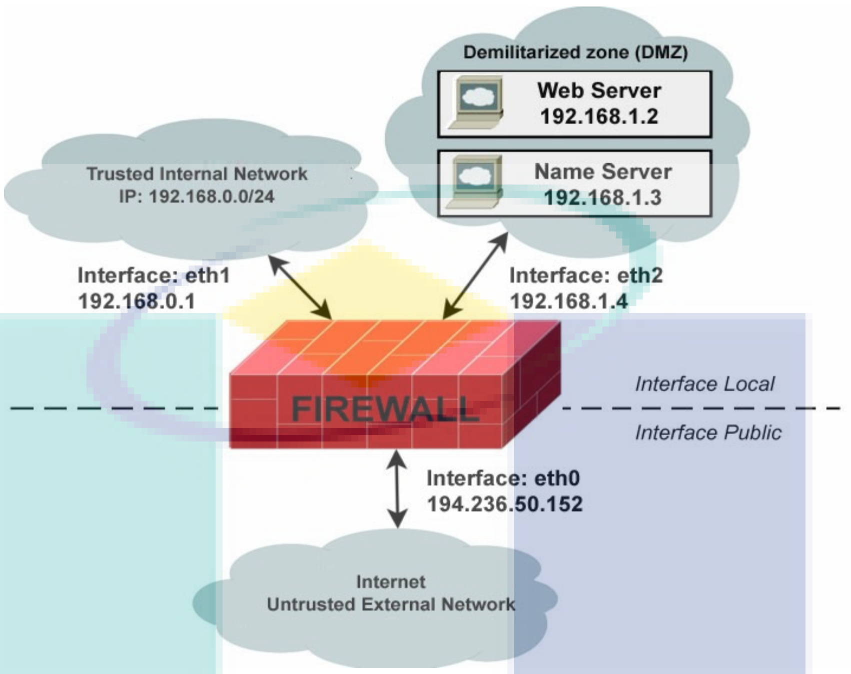


Figure 2.3 Firewall in computer network

Firewall checks every incoming and outgoing network packet to see if it meets the criteria of rules. If it does, firewall will take action to accept, forward, drop or reject the packet network depends the set of rules. Firewalls can filter packets based on source IP address, destination IP address, source port, destination port, protocol and others. Firewalls can filter specific types of network traffic.

The TCP/IP model is older than the Open System Interconnection (OSI) model (Gollman D., 2006; Tibbs R.W. and Oakes E.B., 2006). There are 5 layers in the TCP/IP model. TCP/IP and OSI model is shown in Figure 2.4.

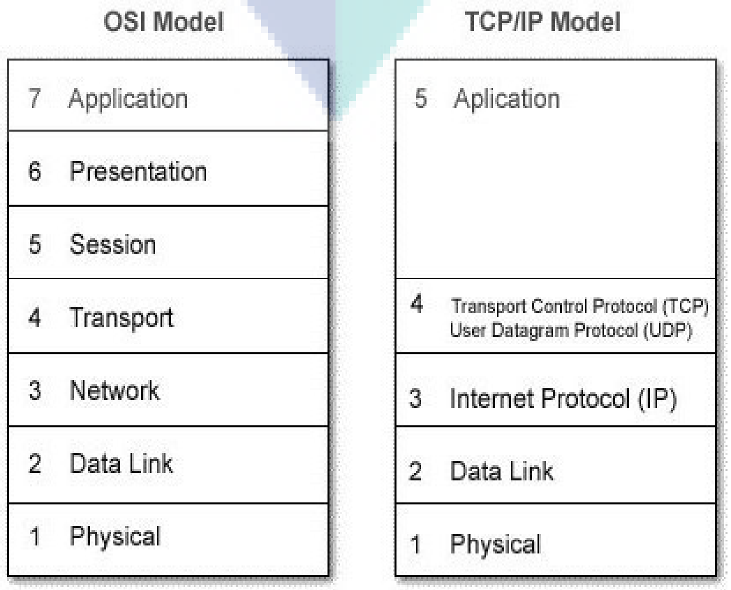


Figure 2.4 The OSI and TCP/IP models (Gollman D., 2006)

The lowest layer in which the firewall can work is layer three. In the OSI model this is the network layer. In TCP/IP it is the Internet Protocol layer. This layer is concerned with routing packets to destination. At this layer a firewall can determine whether a packet is from a trusted source, but cannot be concerned with what it contain packets. Firewalls that operate at the transport layer know about a packet and able to grant or deny access depending criteria set of rules. At the application level, firewall know what is going on and can be very selective in granting access.

2.5.1 Types of Firewalls

Based on mechanism or way of firewalls work, there are four main type of firewall, which are packet-filtering, application level gateway, circuit level gateway and stateful multilayer inspection firewall.

a. Packet Filtering

Packet filtering firewalls work at the Network layer of the OSI model, or the IP layer of TCP/IP. They are usually part of a routing. A router is a device that receives packets from one network and forwards them to another network. Rules specifying which packets are allowed through the firewall and which are dropped. In a firewall, packet of filtering each network packet compared to a set of criteria before it forwarded. Depending on the packet and the criteria of rules, the firewall can drop the packet, forward it or send a message to the source network packet . Rules can include source and destination IP address, source and destination port number and protocol (Gollman D., 2006). Packet filtering firewall is shown in Figure 2.5.

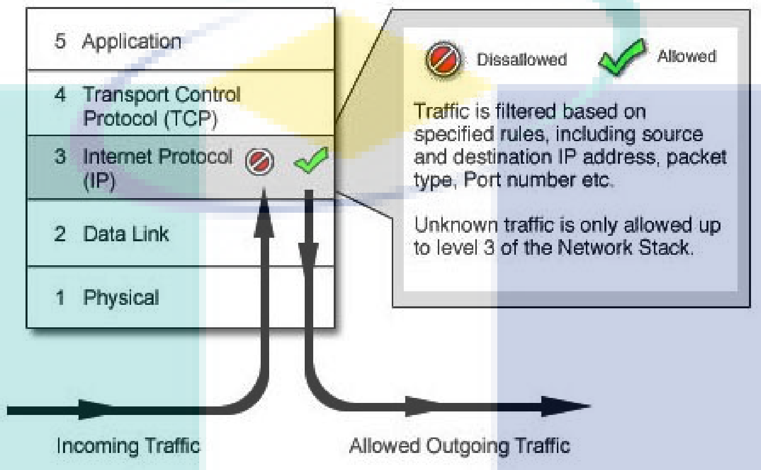

5 Application
4 Transport Control Protocol (TCP)
3 Internet Protocol (IP)
2 Data Link
1 Physical
Dissallowed
Allowed
Traffic is filtered based on specified rules, including source and destination IP address, packet type, Port number etc.
Unknown traffic is only allowed up to level 3 of the Network Stack.
Incoming Traffic
Allowed Outgoing Traffic

Figure 2.5 Packet filtering firewalls (Gollman D., 2006)

For example, network packets using port 80 and destination port 23 to IP address 10.10.1.2. Firewall permit and forward network packet to IP address 10.10.1.2 by using port 80 and reject or drop the network packet by using port 23. This is shown in Figure 2.6.

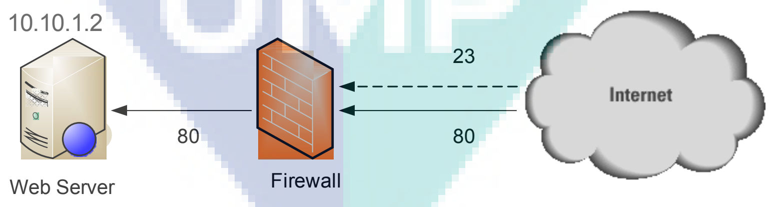


Figure 2.6 Policy packet filtering firewall for 10.10.1.2

b. Application Level Gateway

Application level gateways also called proxies, are similar to circuit-level gateways except that they are application specific. They can filter packets at the application layer of the OSI model. Incoming or outgoing packets cannot access services for which there is no proxy. Application level gateway that is configured to be a web proxy and can not allow FTP, telnet and others. Because they examine packets at application layer, they can filter application specific commands such as http: POST and GET, etc. This cannot be accomplished with packet filtering firewalls or circuit level which do not know anything about the application level. Application level gateways can also be used to log user activity and logins. They offer a high level of security, but have a significant impact on network performance. This is because of context switches that slow down network access dramatically (Mladenic D. et al., 2003). Application level gateway is shown in Figure 2.7.

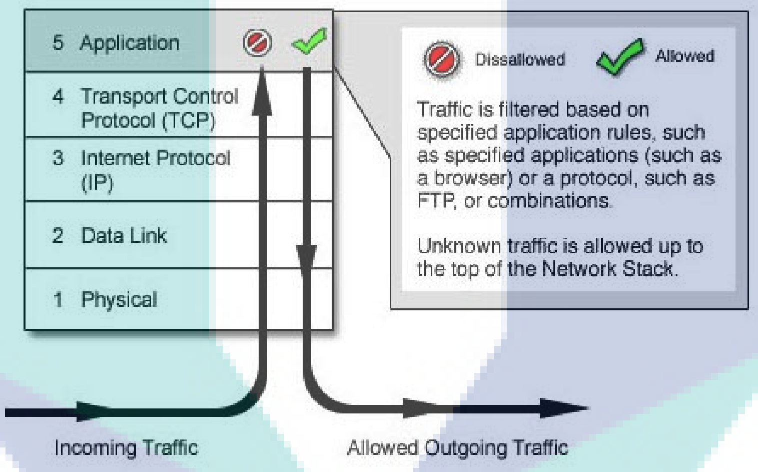

5 Application
4 Transport Control Protocol (TCP)
3 Internet Protocol (IP)
2 Data Link
1 Physical
Dissallowed
Allowed
Traffic is filtered based on specified application rules, such as specified applications (such as a browser) or a protocol, such as FTP, or combinations.
Unknown traffic is allowed up to the top of the Network Stack.
Incoming Traffic
Allowed Outgoing Traffic

Figure 2.7 Application level gateway (Gollman D., 2006)

c. **Circuit Level Gateway**

Circuit level gateways work at the Session layer of the OSI model, or the TCP layer of TCP/IP. This type of firewall is useful to hide information on a protected network packet. Connection between the user and the network is hidden from the user. Users will be confronted directly with the firewall on the connection. Firewall to connect to the network resources are accessed by the user after changing the IP address of the packet transmitted by the two sides. It is like a virtual circuit between users and network resources are accessed. users from the external network can not see the internal network IP addresses in the packets he receives, but the IP address of the firewall. Circuit level gateway is shown in Figure 2.8.

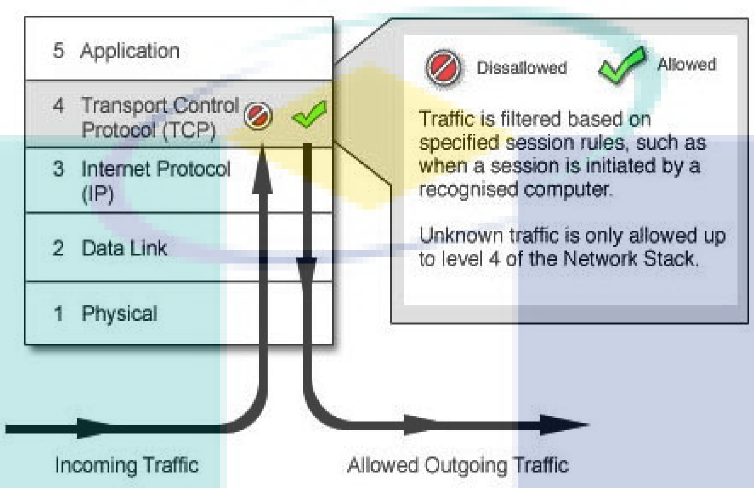

5 Application
4 Transport Control Protocol (TCP)
3 Internet Protocol (IP)
2 Data Link
1 Physical
Dissallowed
Allowed
Traffic is filtered based on specified session rules, such as when a session is initiated by a recognised computer.
Unknown traffic is only allowed up to level 4 of the Network Stack.
Incoming Traffic
Allowed Outgoing Traffic

Figure 2.8 Circuit level gateway

d. Stateful Multilayer Inspection Firewall

Stateful multilayer inspection firewalls combine the aspects of the other three types of firewalls. Packet filtering at the Network layer, determine whether Session packets are legitimate and evaluate contents of packets at the application layer. Stateful multilayer inspection firewalls offer a high level of security, good performance and transparency to end users. They are expensive like Cisco PIX. State multilayer inspection firewall is shown in Figure 2.9.

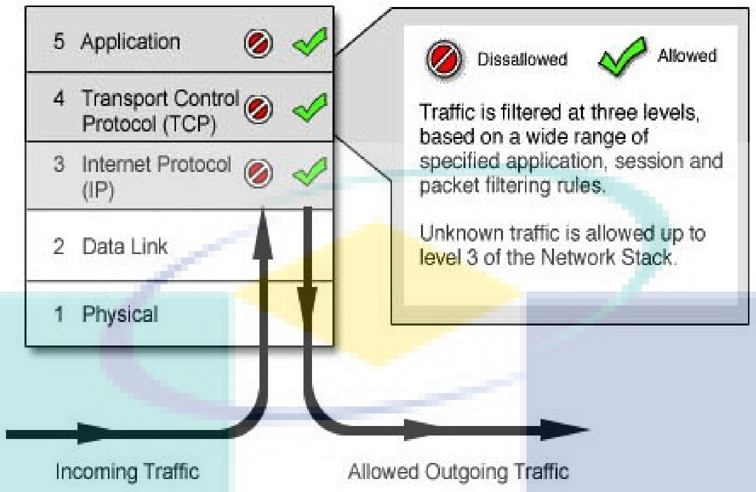

5 Application
4 Transport Control Protocol (TCP)
3 Internet Protocol (IP)
2 Data Link
1 Physical
Dissallowed
Allowed
Traffic is filtered at three levels, based on a wide range of specified application, session and packet filtering rules.
Unknown traffic is allowed up to level 3 of the Network Stack.
Incoming Traffic
Allowed Outgoing Traffic

Figure 2.9 Stateful multilayer inspection firewall (Gollman D., 2006)

2.5.2 Linux Firewalls

In general distribution of the Linux Operating System, there is simple software firewall called the *netfilter* or *iptables* is available. *Iptables* has been part of the Linux kernel since version 2.4 (Joko Y and Onno W.P., 2008). There is difference between *iptables* and *netfilter*. *Netfilter* is the Linux kernel space program code to implement a firewall, either compiled directly into the kernel or included as a set of modules. *Iptables* is the program used for administration of the *netfilter* firewall. *Netfilter* firewall are built through the *iptables* administration command. The *iptables* command implements the firewall policies. *Netfilter* firewalls have three individual tables, which are filter, NAT and *magle* (Flior E. et al., 2010 and Suehring S. and Ziegler R.L., 2006).

The basic syntax for an *iptables* command begins with the *iptables* command itself, followed by one or more options, a chain, a set of match criteria and a target or disposition. The layout of the command largely depends on the action to performed. *iptables* syntax is shown in Figure 2.10.

```
iptables <option> <chain> <matching criteria> <target>
```

Figure 2.10 Linux firewall syntax (Golnabi K. et al., 2006)

There are 3 predefined tables in use by iptables to which can add rules for processing IP packets passing through those tables. These tables are (Al-Shaer E.S. and Hamed H.H., 2004; Jiawei H. and Kamber M., 2006; Joko Y and Onno W.P., 2008 and Suehring S. and Ziegler R.L., 2006):

- INPUT - All network packets to Local Area Network (LAN).
- OUTPUT - All network packets from LAN.
- FORWARD - All network packets incoming to LAN or outgoing from LAN. This machine is called the router.

Iptables check network packet traffic relevant to those tables and a decision is made about what to do with each packet : accept or drop the packets. These actions are referred to as targets. Two most common predefined targets are DROP to drop a packet or ACCEPT to accept a packet.

Firewall can check the packet filtering of pursuant to parameter of IP addresses, protocols (TCP, UDP, ICMP), ports, MAC Address and others (Golnabi K., 2006 and Suehring S. and Ziegler R.L., 2006), so that facilitate the sysadmin for the customize. Following is example of iptables firewall rules is shown in Figure 2.11.

```
-A INPUT –s 203.130.206.5 –p tcp –d 10.10.15.7 --dport 80 –j DROP
```

Figure 2.11 *Iptables* firewall rules

Firewall rule is show in Figure 2.11 explaining to enhance the order by the end of chain (A) for the traffic of incoming to firewall (INPUT) by source IP address (-s)

203.130.206.5 with the type protocol (-p) tcp to destination IP address (-d) 10.10.15.7 and destination port (--dport) 80 hence done by action (- j) dropped (DROP). Policy Firewall rules in Figure 2.11 will do the drop if there is traffic incoming to the firewall by IP address source is 203.230.206.5 type of protocol TCP to destination IP address is 10.10.15.7 and destination port is 80.

A packet was checked each rule in turn, starting at the top, and if it matches that rule, then an action is taken such as accepting (ACCEPT) or dropping (DROP) the packet. If a network packet matches a rule then a network packet is not processed by next rules in the tables. If a network packet is not match any rule, then the default action is taken. This is referred to as the default policy and may be is ACCEPT or DROP the packet (Golnabi K., 2006 and Suehring S. and Ziegler R.L., 2006).

2.5.3 Choosing a Default Packet-Filtering Policy

There are two basic approaches to a default firewall policy (Tibbs R.W. and Oakes E.B., 2006 and Suehring S. and Ziegler R.L., 2006):

- Deny everything by default and explicitly allow selected packets through.
- Accept everything by default and explicitly deny selected packets from passing through.

The deny-everything policy is the recommended approach. This approach makes it easier to set up a secure firewall, but each service and related protocol transaction that must be enabled explicitly. This means that it must understand the communication protocol each service to be enabled. The deny-everything requires more work up to enable Internet access. Some commercial firewall product support only the deny-everything policy. The deny-everything policy is show in Figure 2.12.

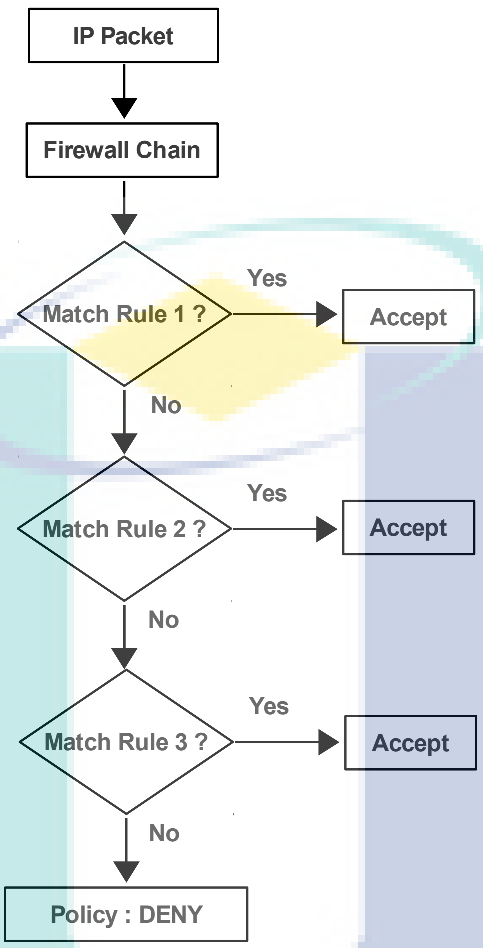


Figure 2.12 The deny-everything-by-default policy (Tibbs R.W. and Oakes E.B., 2006)

The accept-everything policy makes it much easier to get up and running right away, but it anticipate some network packet type to be disabled. The danger is that network packets type is too late to be disabled. Developing a secure accept-everything firewall is much more work and much more difficult. The accept-everything policy is shown in Figure 2.13.

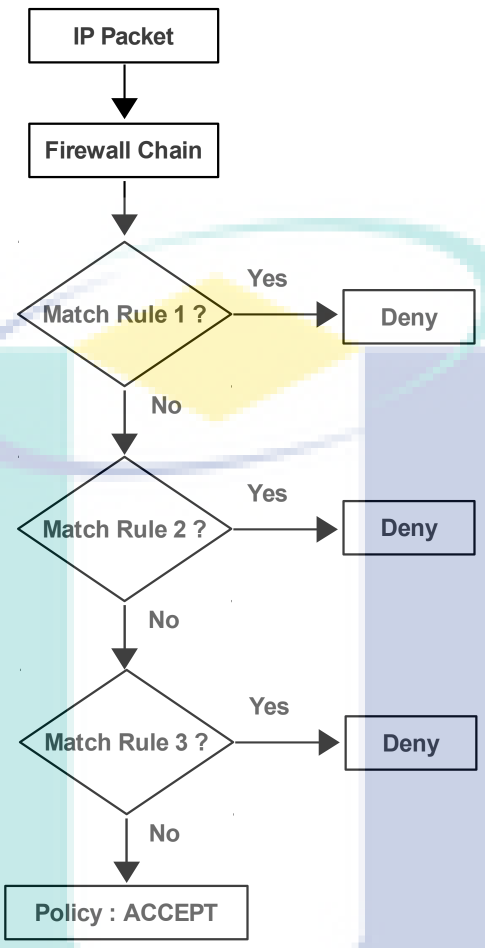


Figure 2.13 The accept-everything-by-default policy (Tibbs R.W.and Oakes E.B.,2006)

Firewall rules are explicitly written and managed to filter out any unwanted traffic coming into or going from the secure network. However, the management of firewall rules has been proven to be complex, error-prone, costly and inefficient for many large-networked organizations (Guan X. and Yun-jie L., 2010; Mehmed M.K. and Jozef Z., 2005; Benelbahri M.A. and Bouhoula A., 2007 and Tibbs R.W. and Oakes E.B., 2006).

The firewall rules are often custom-designed and hand-written by and for human. Firewall tailored to accommodate ever-changing business and market demands of the global internet. Therefore, these rules are in a constant need of updating, tuning and validating to optimize firewall security (Guan X. and Yun-jie L., 2010, Mehmed M.K. and Jozef Z., 2005 and Benelbahri M.A. and Bouhoula A., 2007).

2.6 DATA MINING

Data Mining refers to extracting or "mining" knowledge from large amounts of data. Data mining is the process of employing one or more computer learning techniques to automatically analyze and extract knowledge from data contained within a database. The purpose of a data mining session is to identify trends and pattern data (Dunham and Margareth H., 2002; Duanyang Z. et al., 2010 and Hao-Ran D. and Yun-Hong W., 2007).

The knowledge gained from a data mining session is given a model or generalization of data. However, all data mining methods use induction-based learning. Induction-based learning is the process of forming general concept definition by observing specific examples of concepts to learned.

There are some congeniality of related to data mining (Jiawei H. and Kamber M., 2006):

1. Data mining is to match the data in a model to find information hidden in databases
2. Data mining is the application of algorithms to dig up useful information from the databases
3. Data Mining is process find the pattern in data, where the invention process conducted automatically or semi automatically and pattern found have to be useful
4. Data Mining is process of find information, which is good for depository of big data automatically.
5. Data Mining or Knowledge Discovery in Database (KDD) is information take which hidden, where the information previously the unknown to and have useful potency. This process covers a number of different technical to approach, like clustering, data summarization, learning classification rules.

2.6.1 Knowledge Discovery in Database and Data Mining

Knowledge Discovery in Database (KDD) is a term frequently used interchangeably with data mining. Technically, KDD is the application of the scientific method to data mining (Jiawei H. and Kamber M., 2006). KDD is defined as the non-trivial process of identifying valid, novel, potentially useful and ultimately understandable pattern in data (Duanyang Z., 2010). In addition to performing data mining, a typical KDD process model includes a methodology for extracting and preparing data as well as making decision about actions to be taken once data mining has taken place. When a particular application involves the analysis of large volume of data stored in several locations, data extraction and preparation become the most time-consuming parts of the discovery process. As data mining has become popular name for the broader term like KDD (Dunham and Margareth H., 2002).

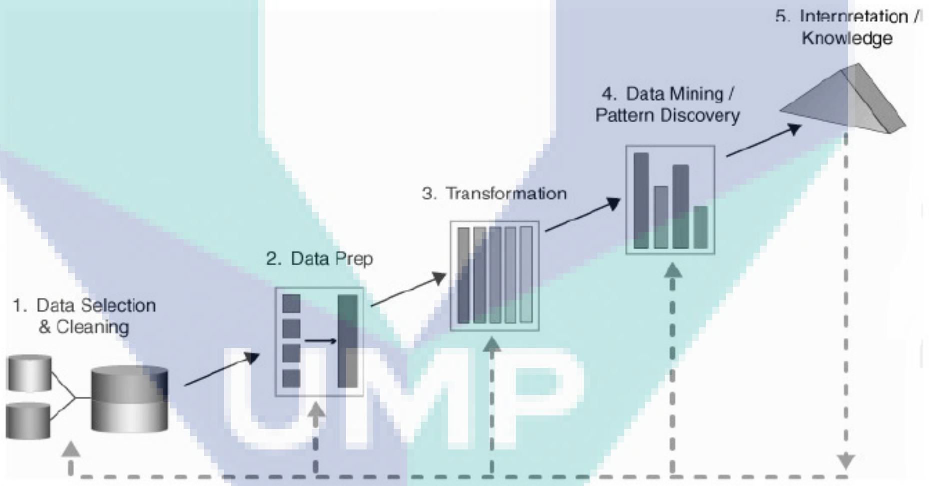


Figure 2.14 Data mining as one part of the KDD (Jiawei H. and Kamber M., 2006)

Today, data are no longer restricted to tuples of numeric or character representation only. The advanced database management technology of today is enable to integrated different types of data, such as image, video text and other numeric as well as non-numeric data, in a probably single database for facilitate processing (Jiawei H. and Kamber M., 2006).

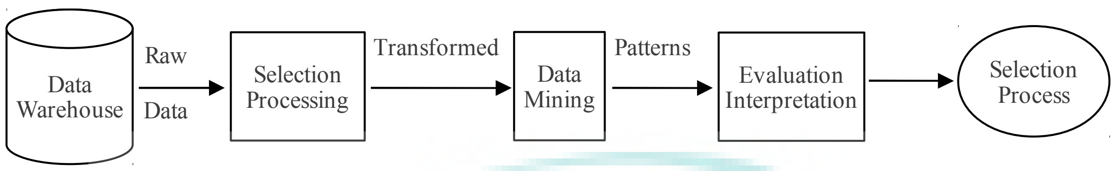


Figure 2.15 The KDD process (Jiawei H. and Kamber M., 2006)

KDD process consists of the steps below (Dunham and Margareth H., 2002) :

1. *Selection of Data* (data selection), selection of relevant data obtained from the database
2. *Data cleaning*, the process of removing noise and inconsistent data or data not relevant.
3. *Data integration,* combining data from various databases into a new database.
4. *Data transformation,* data modified or merged into a format suitable for processing in data mining
4. *Data Mining,* a process in which the method is applied to discover knowledge and hidden data
5. *Pattern evaluation,* identify interesting patterns to be represented into the knowledge-based
6. *Knowledge presentation,* visualization and presentation of knowledge about the techniques used to obtain the knowledge gained users.

2.6.2 Data Mining Techniques

Data Mining refers to process to dig the added of value from a data aggregate in the form of knowledge which during the time unknown in manual (Al-Shaer E.S. and Hamed H.H., 2004). Word mining it is mean the effort to get a few data worth from a large amount of basic data. In consequence of data mining in fact have the long root from science like artificial intelligent, machine learning, statistical and database. There are some techniques in literature of data mining examples association rule, clustering, classification, neural network, genetic algorithm and others (Al-Shaer E.S. and Hamed H.H., 2004 and Berry M.W. And Browne M., 2006).

a. Association Rules

As the name implies, association rule mining techniques are used to discover interesting associations between attributes contained in a database. Examples of associative rule is the purchase of analysis in a supermarket. How is possibility a customer buys bread with milk. Knowledge is the owner of the supermarket stuff can arrange a placement or design marketing strategies by using discount coupons for the combination (Duanyang Z., 2010). For another example such as attached mailing in direct marketing, fraud detection for medical insurance and credit cards, department store floor or shelf planning (Jiawei H. and Kamber M., 2006). For this is reason a limited number of attributes are able to generate hundreds of association rules.

Important or not a association rules can be determined by two parameters. Support the combined percentage of these attributes in the database and confidence the strength of the relationship between attributes in an association rules.

b. Clustering

Clustering, defined broadly, is the grouping of similar object. Clustering is the unsupervised classification of patterns into groups based upon similarity (Berry M.W. And Browne M., 2006). Clustering to group the data without a specific data class. Clustering can be used to provide the class labels of unknown data. Therefore, clustering is called unsupervised learning methods.

The principle of clustering is to maximize the similarity among members of a class and minimize the similarity between clusters. Clustering can be performed on the data which has several attributes that are mapped as a multidimensional space.

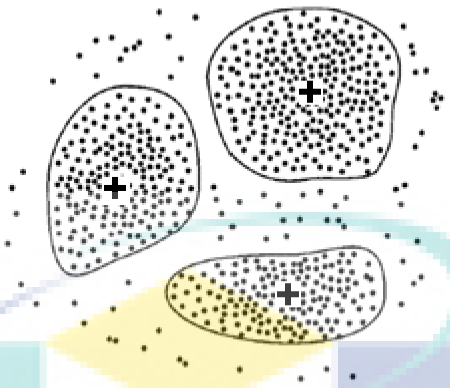


Figure 2.16 Clustering (Jiawei H. and Kamber M., 2006)

Illustrate Clustering is shown in Figure 2.16. The area is two dimension, customer of shop can be grouped to become some cluster with the center cluster shown by positive sign (+). Many algorithms Clustering need the function of distance to measure similarity between data, needed also method for the normalization attributes that have kinds of data.

c. Classification

The input data for a classification is a collection of records. Each record, also knows as instance, characterized by a tuple (*x*,*y*), where *x* is the attribute set and *y* is a special attribute as the class label (Berry M.W. and Browne M., 2006) or also called category or attribute of target. An attribute is a property or characteristic of an object that may vary [Dunham and Margareth H., 2002 and Berry M.W. and Browne M., 2006). For example, eye color varies from person to person, temperature of an object varies over time. Eye is a symbolic attribute with a small number of possible values {brown, black, blue, green, hazel, etc}, while temperature is a numerical attribute with a potentially unlimited number of values.

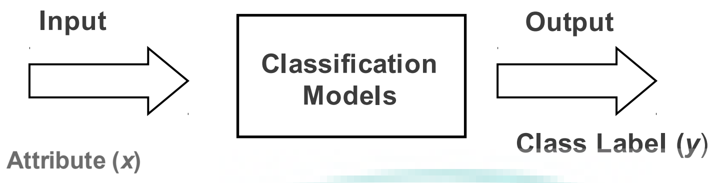


Figure 2.17 Classification as the task of mapping an input attribute set *x* into its class label *y* (Jiawei H. and Kamber M., 2006)

Classification is the task of learning a target function *f* that maps each attribute set *x* to one of the predefined class label *y*, illustration is shown in Figure 2.17. Class label attribute must be discrete (Dunham and Margareth H., 2002; Mladenic D. et al., 2003; Jiawei H. and Kamber M., 2006; Berry M.W. and Browne M, 2006 and Roiger R.J. and Geatz M.W., 2003). This is a key characteristic that distinguishes classification from regression, a predictive modeling is a continuous attribute (Roiger R.J. and Geatz M.W., 2003). The target function is also known as a classification model. A classification model is useful for one predictive modeling (Roiger R.J. and Geatz M.W., 2003) :

✔ **Descriptive Modeling**. Classification model can serve as a clear tool to distinguish between objects of different classes.

Table 2.3 Network Traffics

No	Source IP	Dest IP	Source Port	Dest Port	Protocol	Intrusion
1	122.206.13.100	10.10.1.2	1360	22	TCP	Yes
2	122.306.13.100	10.10.1.2	1425	22	TCP	Yes
3	122.306.13.100	10.10.1.2	1488	22	TCP	Yes
4	122.306.13.100	10.10.1.5	1559	22	TCP	Yes
5	122.306.13.100	10.10.1.5	1620	80	TCP	Yes
6	122.306.13.100	10.10.1.3	2156	80	TCP	Yes
7	203.130.14.20	10.10.1.5	2158	22	TCP	No
8	203.130.14.20	10.10.1.5	1624	22	TCP	No
9	203.130.14.20	10.10.1.3	4207	22	TCP	No
10	203.130.14.20	10.10.1.3	4607	80	TCP	Yes

For example, useful to summarize the data in Table 2.3 and explain the features of a packet is defined as an intrusion or normal.

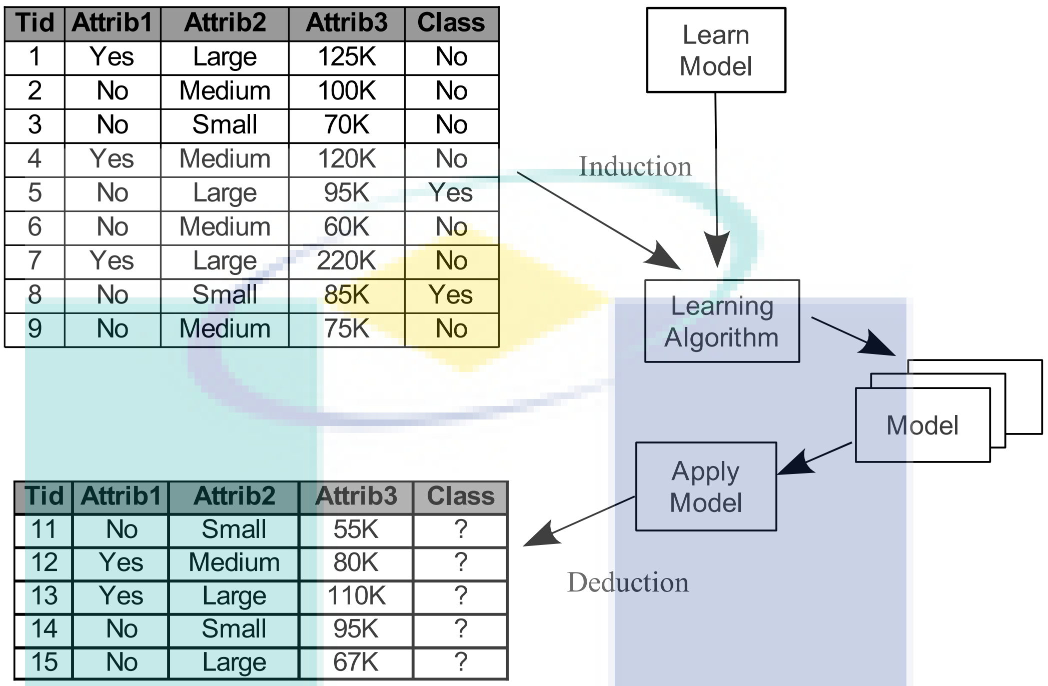
- ✔ **Predictive Modeling**. A classification model can also been used to predict the class label unknown record. As shown in Table 2.3, a classification model can automatically determine the class label when presented with a new dataset where the class labels of unknown. Suppose given some new network packet shown in Table 2.4.

Table 2.4 Predictive modeling

No	Source IP	Dest IP	Source Port	Dest Port	Protocol	Intrusion
1	122.206.13.100	10.10.1.5	1775	80	TCP	?
2	122.206.13.100	10.10.1.3	1775	22	TCP	?

A classification technique is a systematic approach to building classification models from an input data set a such decision tree classifier, rule-based classifier, neural networks, support vector machines and naïve Bayes classifiers. Each technique employs a learning algorithm to identify a model that best fits between relationship and the attribute set and also class label of the input data.

The model generated by a learning algorithm should both fit the input data well and correctly predict the class labels of records that has never seen before. Therefore, a key objective of the learning algorithm is to build models with good generalization capability and models that accurately predict the class labels that previously unknown record [29].



Tid	Attrib1	Attrib2	Attrib3	Class
1	Yes	Large	125K	No
2	No	Medium	100K	No
3	No	Small	70K	No
4	Yes	Medium	120K	No
5	No	Large	95K	Yes
6	No	Medium	60K	No
7	Yes	Large	220K	No
8	No	Small	85K	Yes
9	No	Medium	75K	No

Tid	Attrib1	Attrib2	Attrib3	Class
11	No	Small	55K	?
12	Yes	Medium	80K	?
13	Yes	Large	110K	?
14	No	Small	95K	?
15	No	Large	67K	?

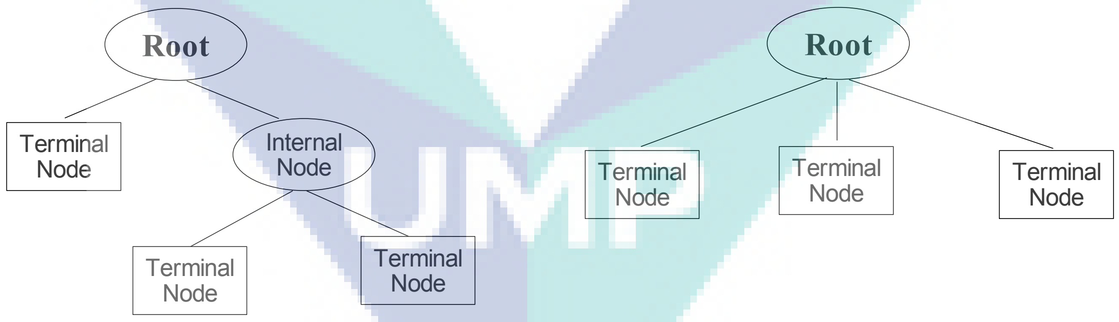
Figure 2.18 General approach for building a classification model (Roiger R.J. and Geatz M.W., 2003)

Figure 2.18 shows a general approach for solving classification problems with predict class that has possibility of two categories that are 'Yes' or 'No'. First, a training data set consisting of records whose class labels are known must be provided. The training set is used to build a classification model, which is subsequently applied to the test set that consists of records with unknown class labels.

2.7 DECISION TREE CLASSIFIER OF DATA MINING

Decision tree classification is one of the fundamental techniques used in data mining (Berry M.W. and Browne M., 2006). A decision tree classifier is one of the most widely need supervised learning methods used for data exploration. It is easy to interpret and can be re-represented as *if-then-else* rules (Mladenic D., 2003; Fayyad U., 1996; Jiawei H. and Kamber M., 2006; Roiger R.J. and Geatz M.W., 2003 and Tan P.N. et al., 2006). *If* `conditions` *then* `class`, with a conjunction of features (attribute values) in the rule condition and a class label in the rule consequent (Mladenic D., 2003). In approximates a function of constant does not require any prior knowledge of data distribution (Berry M.W. and Browne M., 2006).

A decision tree is a tree-like structure used for classification, decision theory, clustering and prediction functions. It describes rule for dividing training data into groups based on the regularities in the data. A decision tree can used for categorical and continuous response variables. When the response variables are continuous, the decision tree often referred to as a regression tree. If the response variables are categorical, it is called a classification tree. However, the same concepts apply to both types of trees. Decision trees are widely used in computer science for data structures, in medical sciences for diagnosis, in botany for classification, in psychology for decision theory, in economy analysis for evaluating investment alternative and anomaly detection. The trees may differ in how the are created. For example, in some cases the trees are created top to bottom, while in other cases the are created form left to right. Decision tree have been described as universal approximates, because they are map linear and nonlinear relationships. However, they do not require as much training data as other universal approximates, such as neural networks.



2.25 (a) Binary Tree   2.25 (b) Nonbinary Tree

Figure 2.25 Types of decision tree (Jiawei H. and Kamber M., 2006)

The tree has three type of nodes as shown in Figure 2.25:

- A **root node** that has no incoming edges and zero or more outgoing edges.

- **Internal nodes**, each of which has exactly one incoming edge and two or more outgoing edges.
- **Leaf** or **terminal nodes**, each of which has exactly one incoming edge and no outgoing edges.

A decision tree consists of a root and internal nodes. The root and the internal nodes labeled with questions in order to find a solution to the problem under consideration. The root node is the first state of a decision tree. This node is assigned to all of examples from the training data. A decision tree is binary if each node is split into two parts. Nonbinary (multi-branch) if each node is split into three or more parts (Jiawei H. and Kamber M., 2006) as shown in Figure 2.25(b).

In decision tree, each leaf node is assigned a class label. The non-terminal nodes, which include the root and other internal nodes, contain attribute test conditions to separate records that have different characteristics (Tan P.N., 2006).

If an internal node can not be split further, it becomes a terminal node. The paths to each internal or terminal node are mutually exclusive, that is no more than one group can possibly be chosen. The process is repeated for each of internal nodes until a completely discriminating tree is obtain or the terminal node is reached.

2.7.1 Decision Tree Algorithm

A decision tree model consists of two parts: creating the tree and applying the tree to database. Decision trees use several different algorithms. The most widely-used algorithms by computer scientists are ID3, C4.5 and C5.0 (Berry M.W. and Browne M., 2006 and Tan P.N., 2006). This algorithm helps decision trees gain credibility and acceptance in the statistics community. Each algorithm employs different mathematical process to determine how to group and rank variables.

The original idea of constructing a decision tree of branch by Hoveland and Hunt. The skeleton of Hunt's methods for constructing a decision tree from a set T of training cases is as follows (Berry M.W. and Browne M., 2006):

Let the classes $\{C_1, C_2, \ldots, C_n\}$. There are three possibilities :

(i) T contains one or more cases, but all belonging to a single class C_j. The decision tree for T is a leaf identifying class C_j.

(ii) T contains no cases. The decision tree is a leaf in this case, but class to be associated with the leaf must be determined from sources other than T.

(iii) T contains cases that belong to a mixture of classes. T is partitioned into subsets T_1, T_2, …, T_k, where T_i contains all cases in T that have outcome O_i of the chosen test. The decision tree for T consists of a decision node identifying the test, and one branch for each possible outcome. This process is applied recursively to each subset of training cases, that the i-th branch leads to the decision tree constructed from the subset T_i of the training cases.

Generally, a decision tree algorithm is most appropriate for the third case. In this case, the decision tree algorithm can be stated as follows (Berry M.W. and Browne M., 2006 and Tan P.N. et al., 2006):

✓ From the training data set, identify a target variable and a set of input variables.

✓ Examine each input variable one at a time:

- To create two or more groupings of the values of the input variables, and measure how similar items are within each group and how different items are between groups.
- Select the grouping that maximizes similarity within groupings and differences between groupings.

✓ Once the groupings have been calculated for each input variable, select the single input variable that maximizes similarity within groupings and differences between groupings.

This process is repeated in each group that contains a percentage of information in the original data. The process is not terminated until all divisible groups have been divided (Berry M.W. and Browne M., 2006).

2.7.2 Motivation of Decision Tree

Decision tree are one of fundamental techniques used in data mining (Berry M.W. and Browne M., 2006). Decision tree is tree-like structures used for classification. Decision trees are easily interpretable and intuitive for humans. They well suited for high-dimensional applications. Decision trees are fast and usually produce high-quality solutions. Decision tree objectives are consistent with the goals of data mining and knowledge discovery.

Decision trees are popular for partitioning data and identifying local structures in small and large databases, which are mostly concern with the discovery of classificatory properties of data tables. Decision tree models have two objectives: producing an accurate classifier, and understanding the predictive structure of the problem. The first goal deal with the accuracy of decision tree classification and the second goal aims at developing understandable patterns that can be interpreted as interesting knowledge (Berry M.W. and Browne M., 2006).

The representation of acquired knowledge in tree form is intuitive and generally easy to an assimilated by humans. The learning and classification step of decision tree induction are simple and fast. In general, decision tree classifier to have good accuracy (Jiawei H. and Kamber M., 2006).

2.8 CONCLUSION

This chapter reviews the concept of NIPS based on NIDS and ID3 algorithm decision tree classifier. Intrusion detection is the act of detecting actions that attempt to compromise the confidentiality, integrity or availability of a resource. There are 4 types of intruder include DoS, probe, U2R and R2L. Each of intruder has specific work.

Intruders observed by looking at the log files. A system that performs automated intrusion detection called IDS. Intrusion should be denied or not allowed to entry in the LAN with reason for security. The intrusion prevention in computer networks is described by a firewall. Firewall can be allow or deny access network packets based on characteristics, such as IP address, port, protocol and others. Firewall can not define a network packet as intrusion. Therefore it is required a method for define whether a network packet as intrusion or not automatically. Decision Tree conduct a learning process from previous network traffics. Decision tree is a tree-like structure used for classification, where each internal node indicates a test on the attribute, each branch represents the test results, and the leaf nodes represent classes or class distributions. Decision tree can to convert to classification rules. These rules can define whether a network packet as a intrusion. These rules are implemented into firewall as intrusion prevention.

CHAPTER 3

METHODOLOGY

3.1 PROPOSED FRAMEWORK

Decision tree classifier to generate rules of intrusion signature patterns where these rules as NIPS that can determine a network packet is intrusion or a normal. Algorithm is used Quinlan's (Mladenic D., 2003; Jiawei H. and Kamber M., 2006; Benelbahri M.A. and Bouhoula, 2007; Berry M.W. and Browne M., 2006 and Tan P.N. et al. 20006) ID3 to construct decision tree. Network traffic logs describe the human behavior which is the intrusion activities or the normal activities. Every network packet in network traffics logs extracted into five attributes as data set for data training of decision tree. The five attributes are source IP address, destination IP address, source port, destination port and protocol. These attributes are most important element in network packet, because these attributes can represent a network packet to denied or dropped that be implemented into firewall policy rules (Predrag Pale T.K., 2007). The results of decision tree training will get rules. These rules can define a network traffic as intrusion, then implemented into firewall rules as prevention. That is a simplified description of a complex entity or process which in this research called framework. The framework in this research using the NIDS and ID3 algorithm of decision tree classifier as shown in Figure 3.1.

There are several reasons for this research using the ID3 algorithm for construct decision tree classifier of data mining:

- Every packet network have object and clearly to identify, such as source IP address, destination IP address, source port, destination port and protocol. Object also called attribute or characteristics.

- Training data for class label attribute is discrete and not numeric. There are only two categories of occurrence in network packet which is either intrusion or not. This can be categorized as a class for decision tree classifier.
- Decision tree classifier using ID3 algorithm generate rules. The rules can determine a intrusion network packet automatically, that is called NIDS. The rules can be implemented into firewall, because they have the same attributes.

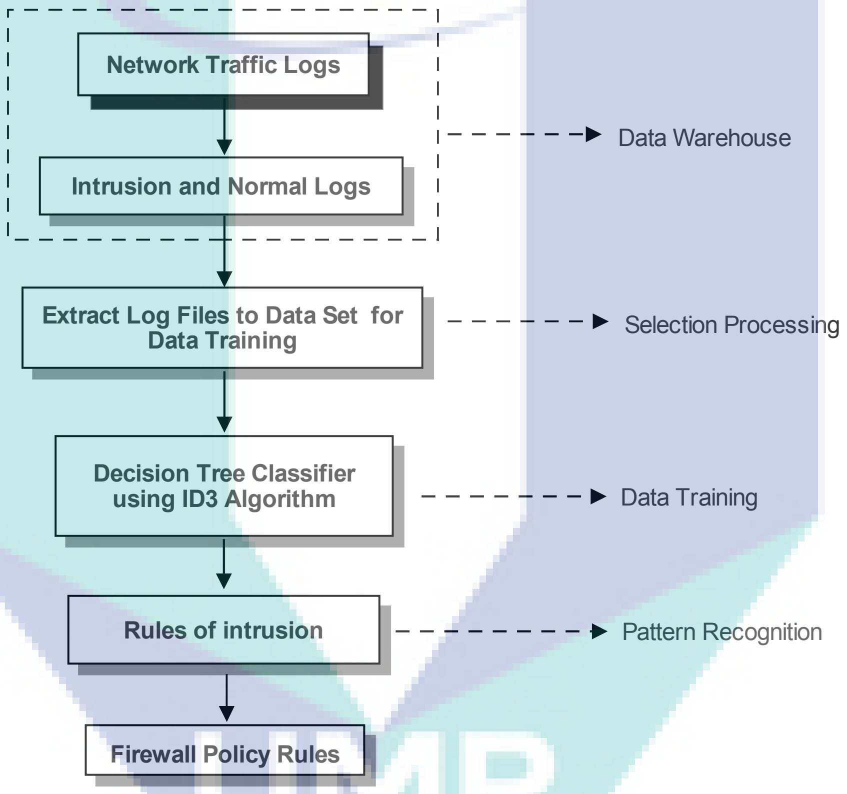


Figure 3.1 Propose framework of NIPS based on NIDS and ID3 algorithm decision tree classifier

3.2 Network Traffic Logs

Log files record all the events on the machine. This files help administrator to monitor various problems such as bugs, network traffics and damage of the machine.

This research, there is a machine as router to record the network traffics. Router is a device that serves to forward packets from one network to another network, so that hosts on a network can communicate with hosts on other networks. Every network packet incoming and outgoing recorded this machine in log files. Illustration network traffic logs is shown in Figure 3.2.

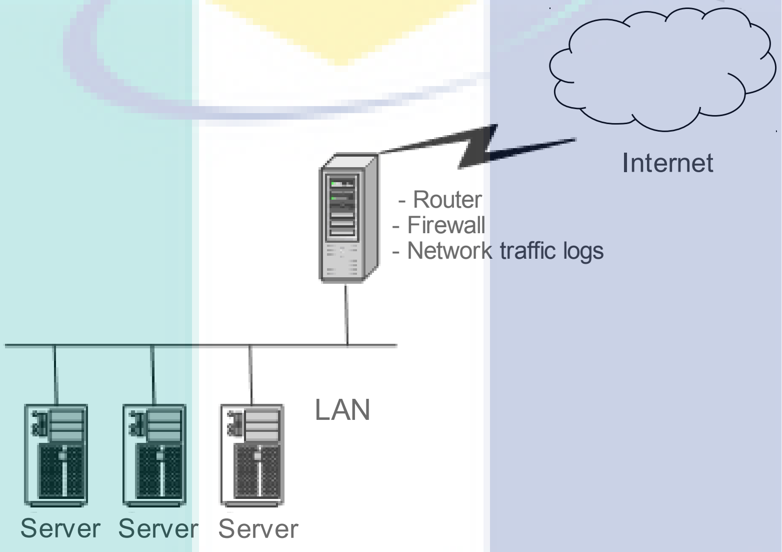


Figure 3.2 Network traffic logs in computer network

3.3 Determine Intrusion or Normal Network Packet using *Snort* NIDS

Determining occurrence of intrusion or normal at network traffic logs can be conducted with two ways :

– See manually by perceiving activities network traffic through log. Follow the example software application of logs files like *syslog*, *syslog_ng*, *tcpdump* and others. Pattern found to see intrusion through log seen modestly, for example there are some times trying to conduct and login of password failed, trying port scan, abundant ping, delivery of abundant package by repeat.
– Using software to determine intrusion activities or normal activities, for example *snort* software.

Snort is an open source network intrusion detection system and can be downloaded for free on the official website `http://www.snort.org`. There are millions of users downloading and more than 300,000 registered users. Snort has become the de facto standard for NIDS (Roozbahani A.R. and Rikhtechi L. , 2010).

Snort application is a combination of network sniffers and log files are applied to analyze the network traffics (Beheshti, M. et al., 2008). *Snort* is the most commonly used signature-based intrusion detection system, capable of performing real time traffic analysis and packet logging on IP networks. *Snort* depends on a pattern matching in *snort* rules and *snort* can only detect attacks known beforehand (Kang H. and Zhang J, 2009).

Snort rules by default placed in the folder `/etc/snort/rules/`. Figure 3.3 is a fragment of the contents `dos.rules` file, one of the *snort* file rules.

```
alert ip $EXTERNAL_NET any -> $HOME_NET any (msg:"DOS IGMP IP Options
validation attempt"; sid:8092; gid:3; rev:3; classtype:attempted-dos;
reference:url,www.microsoft.com/technet/security/bulletin/ms06-007.mspx;
reference:cve,2006-0021; reference:bugtraq,16645; metadata: engine shared,
soid 3|8092;)

alert tcp $EXTERNAL_NET any <> $HOME_NET 389 (msg:"DOS Microsoft Active
Directory LDAP denial of service attempt"; sid:13475; gid:3; rev:1;
classtype:attempted-dos; reference:cve,2008-0088;
reference:url,www.microsoft.com/technet/security/bulletin/ms08-003.mspx;
metadata: engine shared, soid 3|13475;)
```

Figure 3.3 Fragment of *snort* rules in a file `dos.rules`

To edit the rules required a deep knowledge of the protocol, payload intrusions etc. *Snort* application has provided a lot of rules by default and can be added the new rules by downloading periodically at the *snort* official site `http://www.snort.org/snort-rules/#rules`.

This research using snort software as NIDS in Linux OS. *Snort* can determine a network packet is intrusion or normal. nort also produces log files that can be analyzed by admin. All of network traffic is saved by the log files in a folder `/var/log/snort/` and save the log files that intrusion in a folder `/var/log/snort/alert`.

3.4 Retrieving Data Set as Data Training

Network packet consists of the source IP, destination IP, source port, destination port, protocol and others. Intruder performs intrusion with a variety of ways such as seeing the open ports, OS used, the type and version of software application and others. Intruders performs intrusion in step by step process to get information. It causes intruder left many traces in log files. Meanwhile, one IP public represents many other computers to use by translating IP private. This is called Network Address Translation (NAT) (Suehring S. and Ziegler R.L., 2006). NAT was called masquerading. It enables many user do normal activities using source IP address same. Therefore to take normal activities as data training based on source IP address.

This research the way to take intrusion activities and normal activities for data training are :

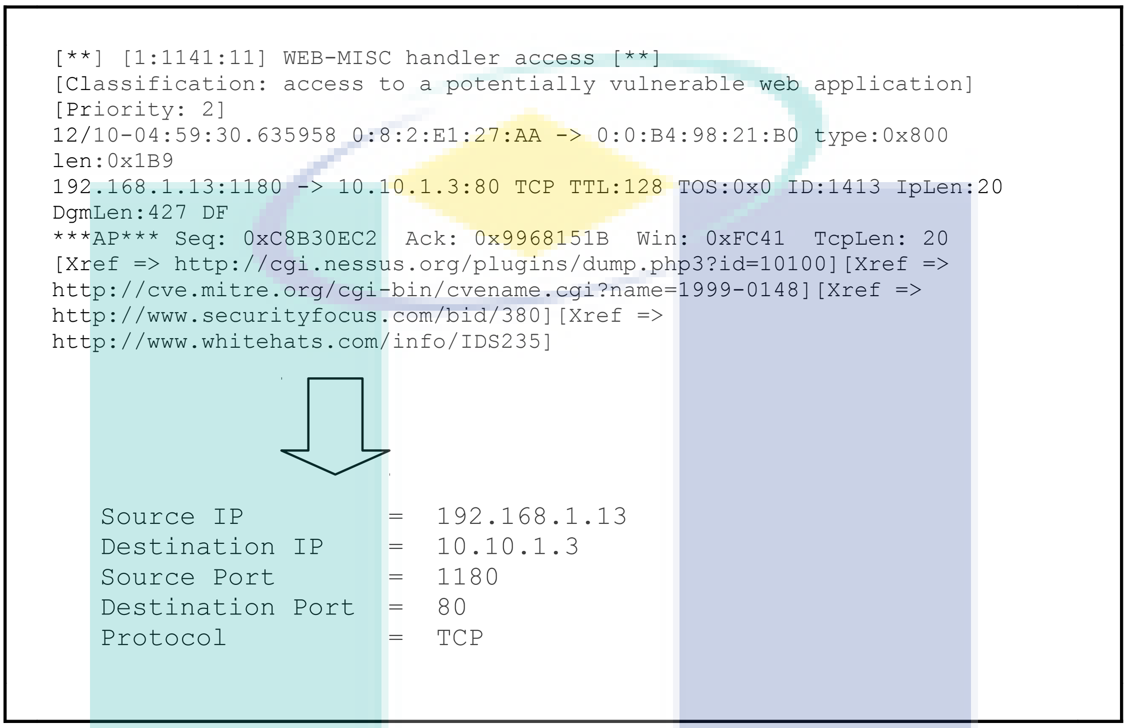
1. For intrusion activities, capture all the network packet did an intrusion.
2. For normal activities, compare every source IP address of network packet normal one by one with network packet intrusion. If has same source IP address then take a network packet normal as data training.

If all network traffic as training data is the intrusion, decision tree is not useful as a classification because all the events are pure as the intrusion. Otherwise if all the network traffic as data training is normal. The function of decision tree is to generate rules intrusion and normal character that can classify the new network traffic is intrusion or normal despite having the same source IP address.

3.5 Extract Log Files

For data training, extract every log files intrusion and normal become five parameters as attributes and categorize 'Yes' or 'No' from intrusion as shown in Table

3.1. The attributes are IP address source, IP address destination, port source, port destination and protocol. For example, extract log files is shown in Figure 3.4



```
[**] [1:1141:11] WEB-MISC handler access [**]
[Classification: access to a potentially vulnerable web application]
[Priority: 2]
12/10-04:59:30.635958 0:8:2:E1:27:AA -> 0:0:B4:98:21:B0 type:0x800
len:0x1B9
192.168.1.13:1180 -> 10.10.1.3:80 TCP TTL:128 TOS:0x0 ID:1413 IpLen:20
DgmLen:427 DF
***AP*** Seq: 0xC8B30EC2  Ack: 0x9968151B  Win: 0xFC41  TcpLen: 20
[Xref => http://cgi.nessus.org/plugins/dump.php3?id=10100][Xref =>
http://cve.mitre.org/cgi-bin/cvename.cgi?name=1999-0148][Xref =>
http://www.securityfocus.com/bid/380][Xref =>
http://www.whitehats.com/info/IDS235]
```

```
    Source IP          =  192.168.1.13
    Destination IP     =  10.10.1.3
    Source Port        =  1180
    Destination Port   =  80
    Protocol           =  TCP
```

Figure 3.4 Extract log files of network traffics

For easier, dataset results from the extract to data training is formed into a table. Put the value attribute for each column plus one column as a class worth 'Yes' or 'No' of intrusion. Table 3.1 shows the results of the extract formed into a table.

Table 3.1 Extract Log files into table form

No	Source IP	Dest IP	Source Port	Dest Port	Protocol	Intrusion
1	192.168.1.13	10.10.1.3	1180	80	TCP	Yes
2	….	...	...	...	...	...
…	…	…	…	…	…	…

3.6 ID3 Algorithm

ID3 builds a decision tree from a fix set of examples. The resulting tree is used to classify future samples. This research has five attributes and belongs to a class 'Yes' or 'No' of intrusive. The decision node is an attribute test each branch (to another decision tree) being a possible value of the attribute. ID3 uses information going to help it decide which attribute goes into a decision node.

The calculation for information gain is the most difficult part of this algorithm. ID3 performs a search whereby the search states are decision trees and the operator involves adding a node to an existing tree. It uses information gain to measure the attribute to put in each node, and performs a greedy search using this measure of worth. The ID3 algorithm that implemented in this study goes as follows:
Given a set of examples, *S*, categorized in categories c_i, then:

1. Choose the root node to be the attribute, *A*, which scores the highest for information gain relative to *S*.
2. For each value *v* that *A* can possibly take, draw a branch from the node.
3. For each branch from *A* corresponding to value *v*, calculate S_v. Then:
    - If S_v is empty, choose the category $c_{\textbf{default}}$ which contains the most examples from *S*, and put this as the leaf node category which ends that branch.
    - If S_v contains only examples from a category *c*, then put *c* as the leaf node category which ends that branch.
    - Otherwise, remove *A* from the set of attributes which can be put into nodes. Then put a new node in the decision tree, where the new attribute being tested in the node is the one which scores highest for information gain to S_v. This new node starts the cycle again (from 2), with *S* replaced by S_v in the calculations and the tree gets built iteratively like this.

The algorithm terminates either when all the attributes have been exhausted, or the decision tree perfectly classifies the examples. The diagram to explain the ID3 algorithm is shown in Figure 3.5.

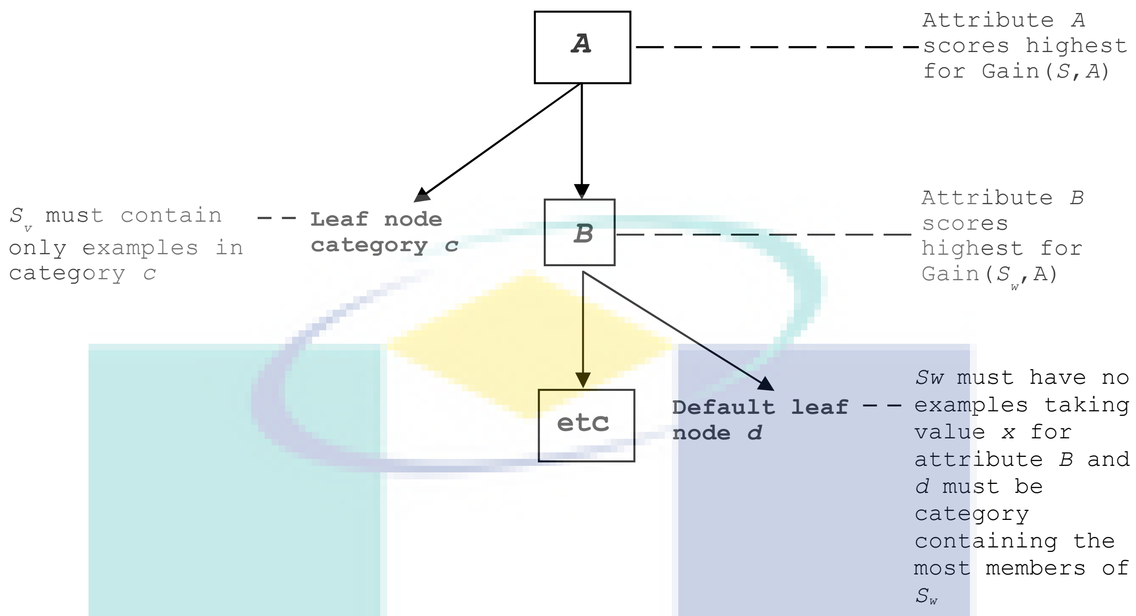

A
Attribute A scores highest for Gain(S,A)
S_v must contain only examples in category c
Leaf node category c
B
Attribute B scores highest for Gain(S_w,A)
etc
Default leaf node d
Sw must have no examples taking value x for attribute B and d must be category containing the most members of S_w

Figure 3.5 Construct decision tree

3.6.1 Entropy

Given a binary categorization, C, and a set of examples, S, for which the proportion of examples categorized as positive by C is p_+ and the proportion of examples categorized as negative by C is p_- , then the entropy of S is:

$$E(S) = -p_+ \log_2(p_+) - p_- \log_2(p_-) \quad \ldots\ldots\ldots\ldots\ldots\ldots(3.1)$$

Given a categorization, C into categories $c_1, \ldots, c_n$, and a set of examples, S, for which the proportion of examples in c_i is p_i, then the entropy of S is:

$$E(S) = \sum_{i=1}^{n} -p_i \log_2(p_i) \quad \ldots\ldots\ldots\ldots\ldots\ldots(3.2)$$

If p gets close to zero, log(p) becomes a big negative number. Entropy calculates the disorder in the data, if entropy is low score it means good, as it reflects desire to reward categories. Similarly, if p gets close to 1, then the $\log_2(p)$ part gets very close to zero, so the overall value gets close to zero (Dunham and Margareth H., 2002; Mladenic

D., 2003; Jiawei H. and Kamber M., 2006 and Berry M.W. and Browne M., 2006). Note that 0*log₂(0) is taken to be zero.

3.6.2 Information Gain

The following measure calculates entropy value for a given attribute, A, with respect to a set of examples, S. Note that the values of attribute A will range over a set of possibilities which call Values(A), and that, for a particular value from that set, v, write S_v for the set of examples which have value v for attribute A, then entropy S of A is:

$$E(S,A) = \sum_{v \in Value(A)} \frac{|S_v|}{|S|} E(S_v) \quad \text{...(3.3)}$$

The information gain of attribute A, relative to a collection of examples, S, is calculated as:

$$\begin{aligned} Gain(S,A) &= E(S) - E(S,A) \\ &= E(S) - \sum_{v \in Value(A)} \frac{|S_v|}{|S|} E(S_v) \quad \text{........................(3.4)} \end{aligned}$$

3.7 Rule Extraction IF-THEN

Calculation having taken steps by using ID3 algorithm hence formed by decision tree example as shown in Figure 3.6.

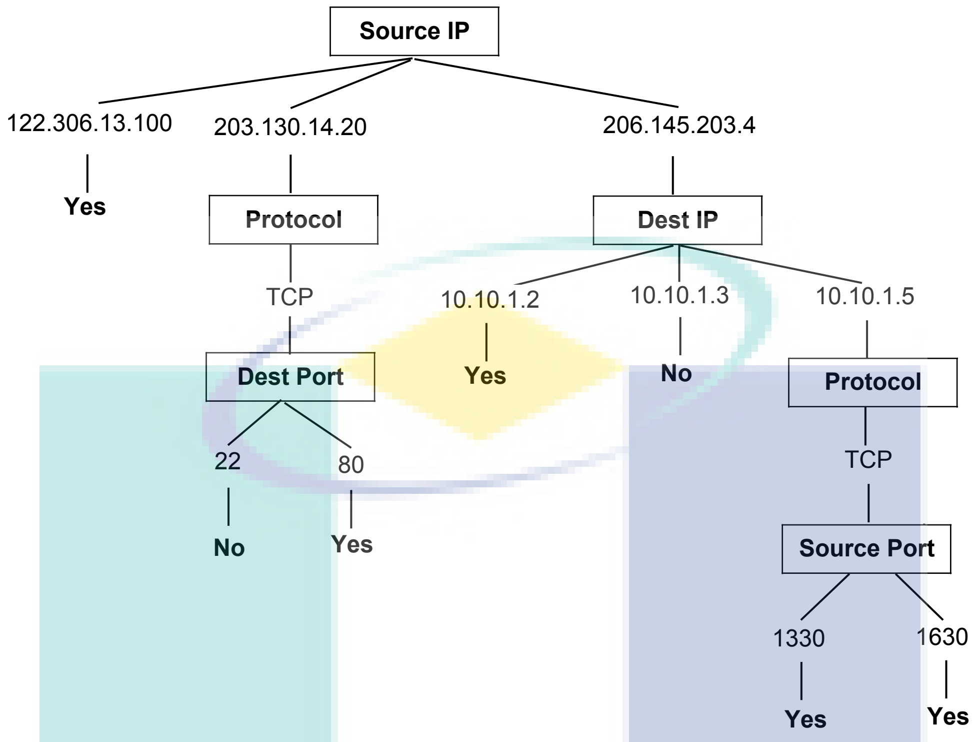


Figure 3.6 Decision tree of network traffics

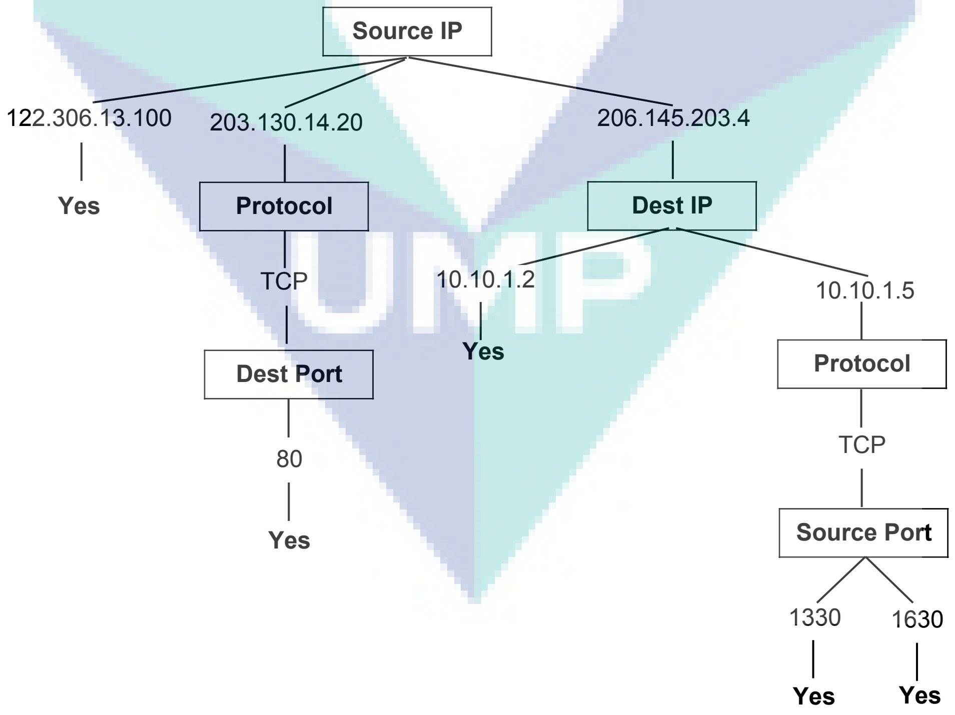


Figure 3.7 Pruning decision tree network traffic for NIDS

Decision tree classifier made moderate with only taking pattern which occurrence intrusive ' Yes' at final node and this describe rules of intrusion signature pattern. Decision tree can simplified by pruning all connections are assumed to be normal and not classified as intrusion. Figure 3.7 shows pruning decision tree network traffics.

The Decision trees can become interpretation rule-based classifier by extracting IF-THEN rules (Mladenic D., 2003; Jiawei H. and Kamber M., 2006; Roiger R.J. and Geatz M.W., 2003 and Tan P.N. et al., 2006). In comparison with a decision tree, the IF-THEN rules may be easier for humans to understand (Jiawei H. and Kamber M., 2006).

To extract rules from a decision tree, one rule is created for each path from the root to a leaf node. Each splitting criterion along a given path is logically AND form the rule antecedent ("IF" part). The leaf node holds the class prediction, forming the rule consequent ("THEN" part) (Jiawei H. and Kamber M., 2006).

This is example extracting classification rules from a decision tree. The decision tree is shown in Figure 3.7 can converted to classification IF-THEN rules by tracing the root node to each leaf node in the tree is shown in Figure 3.8.

```
R1  :  IF (Source IP = 122.306.13.100) THEN Intrusion = Yes
R2  :  IF (Source IP = 203.130.14.20) AND (Protocol = TCP) AND (Dest Port = 80)
        THEN Intrusion = Yes
R3  :  IF (Source IP = 206.145.206.4) AND (Dest IP = 10.10.1.2) THEN Intrusion = Yes
R4  :  IF (Source IP = 206.145.206.4) AND (Dest IP = 10.10.1.5) AND (Protocol = TCP) AND
       (Source Port = 1330) THEN Intrusion = Yes
R5  :  IF (Source IP = 206.145.206.4) AND (Dest IP = 10.10.1.5) AND (Protocol = TCP) AND
       (Source Port = 1630) THEN Intrusion = Yes
```

Figure 3.8 The decision tree converted to classification IF-THEN rules

3.8 Rules Implemented into Firewall Rules

Decision tree has to generate rules. If there is network packet match with one of rules, the network packet is intrusion. For security, intrusion network packet will be dropped and not forward into LAN. These rules in Figure 3.8 can be implemented in firewall rules as shown in Figure 3.9.

```
R1   :  -A FORWARD -s 122.306.13.100 -j DROP
R2   :  -A FORWARD -s 203.130.14.20 -p tcp --dport 80 -j DROP
R3   :  -A FORWARD -s 206.145.206.4 -d 10.10.1.2 -j DROP
R4   :  -A FORWARD -s 206.145.206.4 -d 10.10.1.5 –p tcp --sport 1330 -j DROP
R5   :  -A FORWARD -s 206.145.206.4 -d 10.10.1.5 –p tcp --sport 1630 -j DROP
```

Figure 3.9 Rules to be implemented into firewall rules

Firewall policy rules as shown in Figure 3.9 describe that every network packet match rules will DROP. This action prevention of intrusion network packet.

3.9 CONCLUSION

This chapter explains propose NIPS based on NIDS and ID3 algorithm decision tree classifier. The network traffic logs as data training have two categories that are intrusion or normal. Network traffics extracts five attributes include source IP, destination IP, source port, destination port and protocol. Decision tree is construct by using ID3 algorithm. Decision tree generate rules of intrusion, where rules can determine automatically network packet either intrusion or normal. Rules of intrusion was implemented into firewall as prevention action.

CHAPTER 4

IMPLEMENTATION

4.1 NIPS BASED ON NIDS AND ID3 ALGORITHM DECISION TREE CLASSIFIER ENVIRONMENT

Internet is made up of several computer network connections. This connection then expanded and spread all over the world. This research takes only a few clients and servers that can represent a large computer network like the Internet. Client request to the server and some tried intrusion to the server. The most important in this research obtain data training that is intrusion network packets in the network traffics and does not depend on the size of a computer network. Machines as routers and firewalls that important to capture network traffic in the log files and take action for network packet. This machine can be implemented into a large computer network where the log files as data training generated reflects the network topology used.

The implementation is built 3 Local Area Network (LAN) as client is connected to the LAN as the server computer. There is 3 computer for servers in a LAN. Each of LAN connected through a router. Each computer server has application server same that is *SSH* server, *Apache* web server, *MySQL* database server, *Sendmail* Mail Server and *Squirellmail* Webmail. *Squirellmaill* is Webmail to provide email service through a URL or web browser. Machine computer for the router and firewall applications have a *Dynamic Host Configuration Protocol* (*DHCP*) Server, *Berkeley Internet Name Domain* (*BIND*) Name Server and *Snort* software for network traffic logs and NIDS. All network traffic logs will be recorded in this machine as router and firewall using *Snort* software. Topology network and all information shown in Figure 4.1.

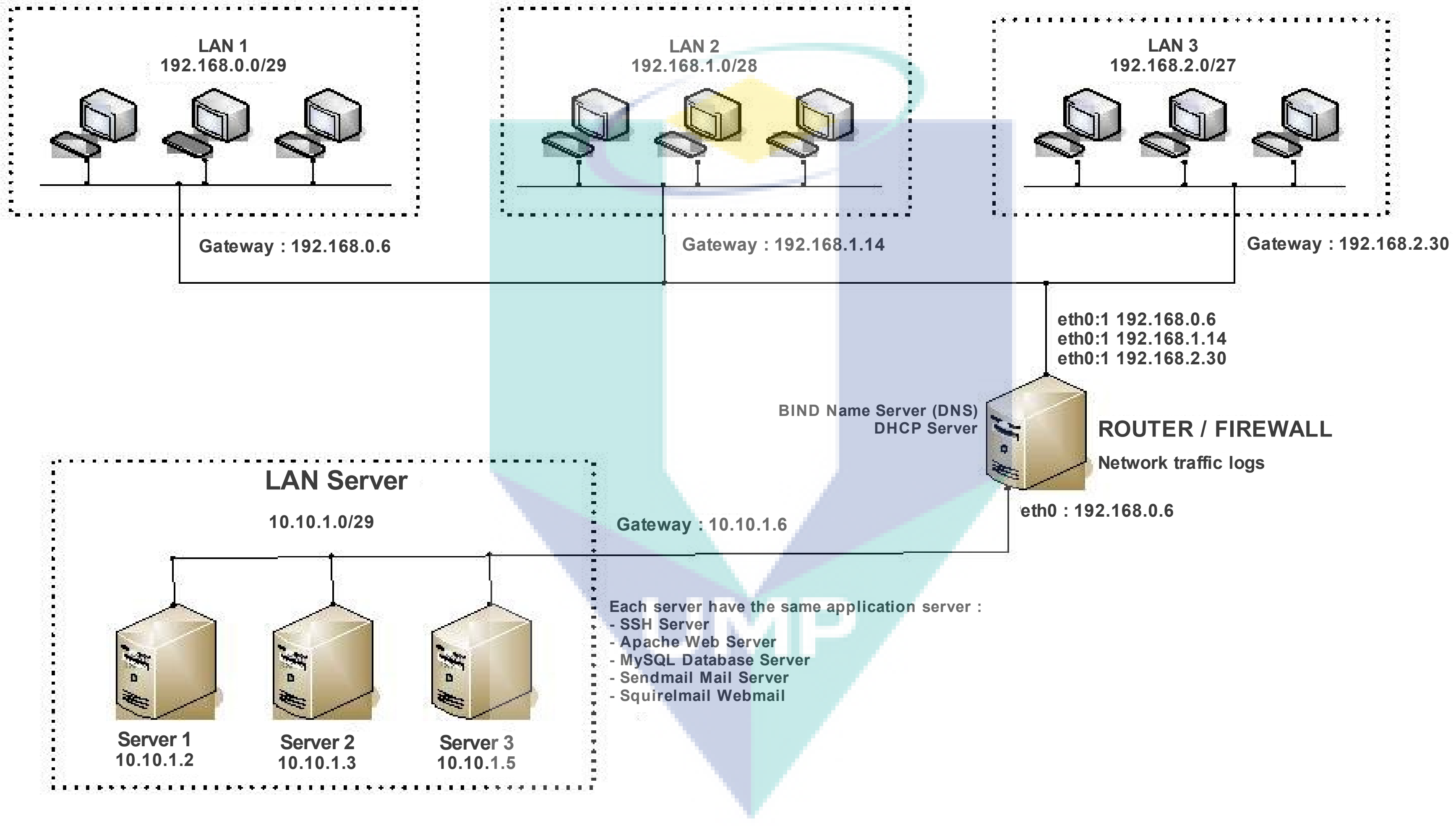


Figure 4.1 Network topology

4.1.1 Setting Server

A computer server provide many services to the client. In addition, server is to detect intrusive from the client too. Each server uses Slackware Linux 12.1 Operating System kernel 2.6.27.1. The same hardware specification for all servers in LAN is shown in table 4.1.

Table 4.1 Server components specification

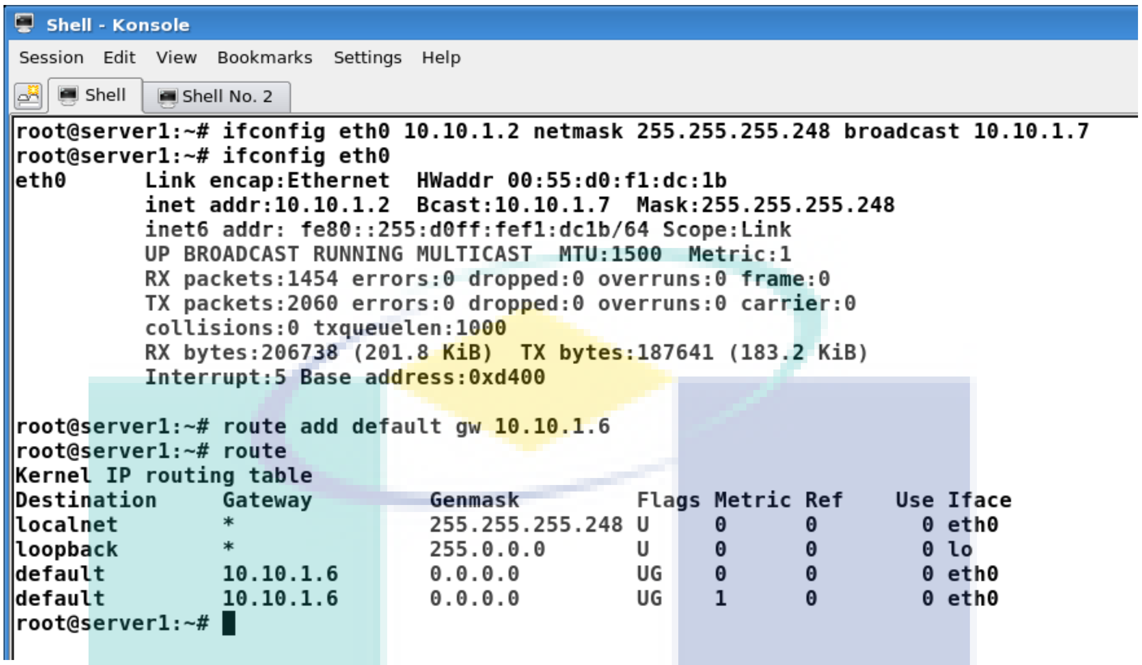
Hardware	Specification
Processor	AMD Duron 1200+
Mainboard	ECS K7SEM
Memory	2x@256 MB
Hard Disk	80 GB
VGA Card	AGP NVDIA GeForce2 MX 400
Network Card	Realtek RTL8139

Computer as the server is in LAN 10.10.1.0/29. There are 3 servers. IP address and hostname of each computer is shown in Table 4.2.

Table 4.2 IP address and server hostname

IP Address	Hostname
10.10.1.2	server1
10.10.1.3	server2
10.10.1.5	server3

Setting IP address and gateway have done by using the command `ifconfig` and `route` on the Linux command line interface. Gateway is the nearest route to the LAN. Setting IP address and gateway is shown in Figure 4.2.



```
root@server1:~# ifconfig eth0 10.10.1.2 netmask 255.255.255.248 broadcast 10.10.1.7
root@server1:~# ifconfig eth0
eth0      Link encap:Ethernet  HWaddr 00:55:d0:f1:dc:1b
          inet addr:10.10.1.2  Bcast:10.10.1.7  Mask:255.255.255.248
          inet6 addr: fe80::255:d0ff:fef1:dc1b/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:1454 errors:0 dropped:0 overruns:0 frame:0
          TX packets:2060 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:206738 (201.8 KiB)  TX bytes:187641 (183.2 KiB)
          Interrupt:5 Base address:0xd400

root@server1:~# route add default gw 10.10.1.6
root@server1:~# route
Kernel IP routing table
Destination     Gateway         Genmask         Flags Metric Ref    Use Iface
localnet        *               255.255.255.248 U     0      0        0 eth0
loopback        *               255.0.0.0       U     0      0        0 lo
default         10.10.1.6       0.0.0.0         UG    0      0        0 eth0
default         10.10.1.6       0.0.0.0         UG    1      0        0 eth0
root@server1:~# █
```

Figure 4.2 Setting IP address and gateway

There are several ways to setting IP address:

– Use command `ifconfig`. For easily command setting IP address is written in the `rc.local` file. This file in the directory `/etc/rc.d/rc.local`. This is a local startup command, where every time booting all command in the `rc.local` file is executed.

– Setting static IP address by tools, use command `netconfig` then there is dialog box.

– Setting static IP address use script in `rc.inet1.conf` file. In Slackware that is file in folder `/etc/rc.d/rc.inet1.conf`.

Each computer has same application server. Application server is shown in Table. 4.3.

Table 4.3 Application server

Aplication Server	Software	Port Used
SSH Server	ssh	22
Web Server	apache	80
Database	mysql	3306
Mail Server	sendmail	143, 110, 25
Webmail	squirrellmail	80, 143, 110, 25

Application server will run through the port as a service to the client. This research, these ports are destination ports, one of the attribute data training. These ports has some value as shown in Table 4.3. It is a target for the intruder to access system.

4.1.2 Setting Router and Firewall

Router is a computer or machine that forward packets from one or more than one LAN to another LAN. Router has a broader function than the gateway. Router connect between gateway on computer network. Figure 4.3 shows the setting IP address computer and router.

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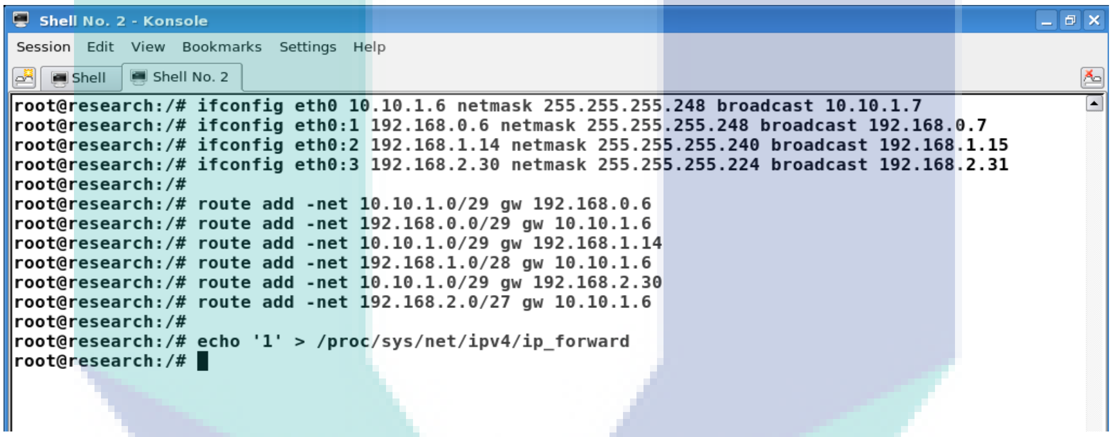

```
root@research:/# ifconfig eth0 10.10.1.6 netmask 255.255.255.248 broadcast 10.10.1.7
root@research:/# ifconfig eth0:1 192.168.0.6 netmask 255.255.255.248 broadcast 192.168.0.7
root@research:/# ifconfig eth0:2 192.168.1.14 netmask 255.255.255.240 broadcast 192.168.1.15
root@research:/# ifconfig eth0:3 192.168.2.30 netmask 255.255.255.224 broadcast 192.168.2.31
root@research:/#
root@research:/# route add -net 10.10.1.0/29 gw 192.168.0.6
root@research:/# route add -net 192.168.0.0/29 gw 10.10.1.6
root@research:/# route add -net 10.10.1.0/29 gw 192.168.1.14
root@research:/# route add -net 192.168.1.0/28 gw 10.10.1.6
root@research:/# route add -net 10.10.1.0/29 gw 192.168.2.30
root@research:/# route add -net 192.168.2.0/27 gw 10.10.1.6
root@research:/#
root@research:/# echo '1' > /proc/sys/net/ipv4/ip_forward
root@research:/# █
```

Figure 4.3 Setting IP address and router

Enter command line is shown in Figure 4.3 above in file `/etc/rc.d/rc.local` as the local startup command.

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Table 4.4 Router and firewall components specification

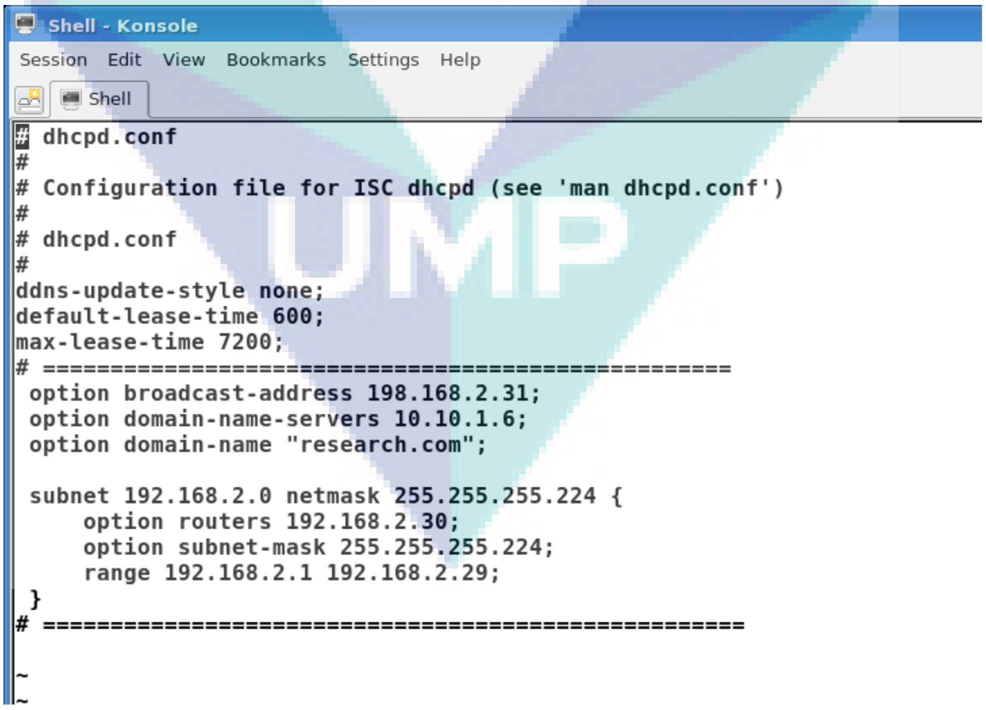
Hardware	Specification
Processor	Core 2 Dou 2.0 GHz
Memory	1GB
Hard Disk	250 GB
Network Card	Realtek RTL 8111/8168B

Computer specification for the router and firewall is shown Table 4.4. In the implementation computer as router and firewall also as a *DHCP* Server, Name Server, Firewall and network traffic logs. DHCP server functions to provide automatically IP address, netmask, gateway and *Domain Name System* (DNS) for client. Name Server will be a service that translates IP address to a system for name as well as the name of the system to the IP address. The name system in this hierarchy called the DNS. Software application at computer router and firewall is shown in Table 4.5.

Table 4.5 Software applications in computer as router and firewall

Software Aplication	**Version**	**Port**
DHCP Server	dhcp-3.0.3	67
Name Server	bind-9.2.3	53
Firewall	iptables-1.2.10	-
Log Files	snort-2.8..3.1 (`/var/log/snort`)	-

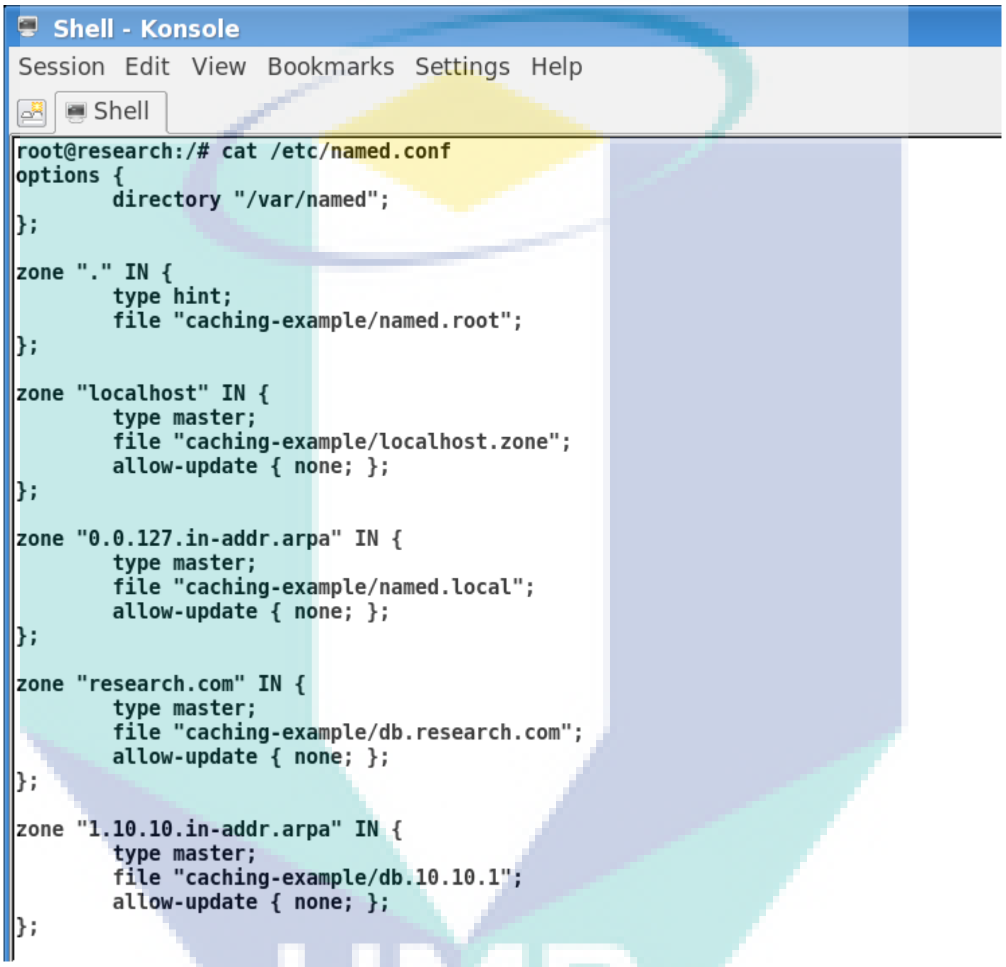
DHCP server used for one LAN, because computer has only one network card that is 'eth0'. The configuration of DHCP is shown Figure 4.4.



```
# dhcpd.conf
#
# Configuration file for ISC dhcpd (see 'man dhcpd.conf')
#
# dhcpd.conf
#
ddns-update-style none;
default-lease-time 600;
max-lease-time 7200;
# ===================================================
 option broadcast-address 198.168.2.31;
 option domain-name-servers 10.10.1.6;
 option domain-name "research.com";

 subnet 192.168.2.0 netmask 255.255.255.224 {
     option routers 192.168.2.30;
     option subnet-mask 255.255.255.224;
     range 192.168.2.1 192.168.2.29;
 }
# ====================================================

~
~
```

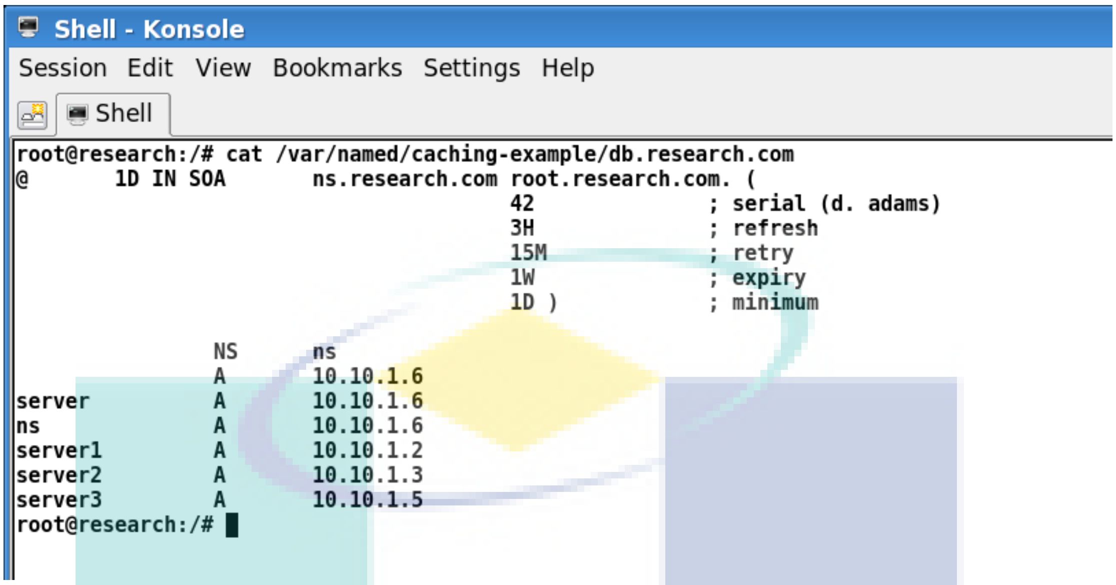
Figure 4.4 Configuration of DHCP server

Local DNS makes the computer host easily known in the LAN. In this implementation the domain name is 'research.com'. The configuration of DNS are shown in Figure 4.5, Figure 4.6 and Figure 4.7.



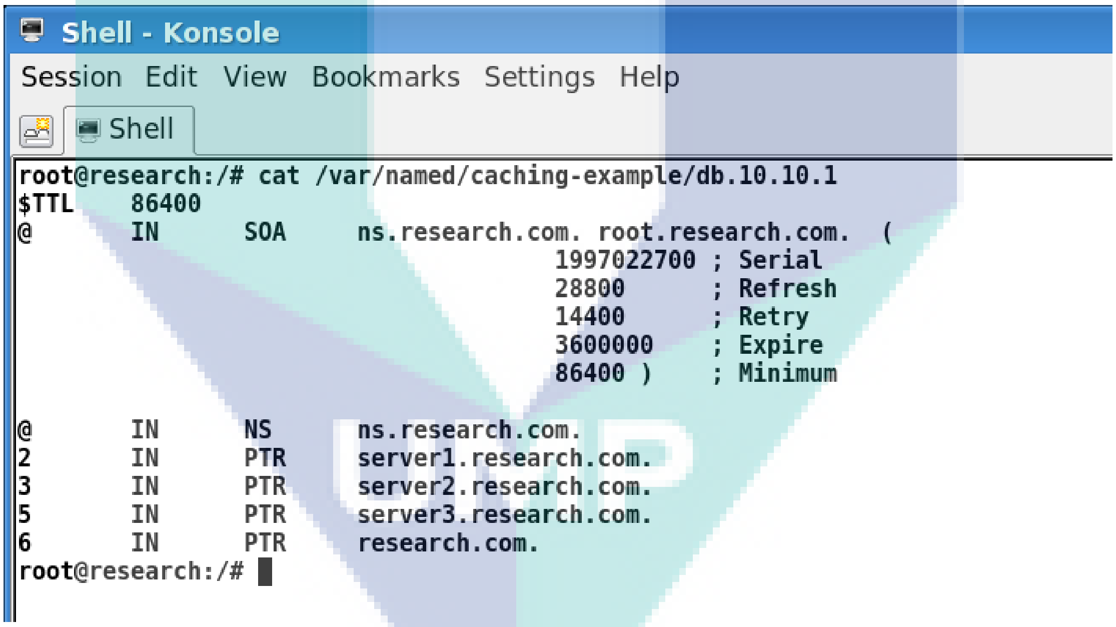
```
root@research:/# cat /etc/named.conf
options {
        directory "/var/named";
};

zone "." IN {
        type hint;
        file "caching-example/named.root";
};

zone "localhost" IN {
        type master;
        file "caching-example/localhost.zone";
        allow-update { none; };
};

zone "0.0.127.in-addr.arpa" IN {
        type master;
        file "caching-example/named.local";
        allow-update { none; };
};

zone "research.com" IN {
        type master;
        file "caching-example/db.research.com";
        allow-update { none; };
};

zone "1.10.10.in-addr.arpa" IN {
        type master;
        file "caching-example/db.10.10.1";
        allow-update { none; };
};
```

Figure 4.5 Configure DNS server zone at `/etc/named.conf`



```
root@research:/# cat /var/named/caching-example/db.research.com
@       1D IN SOA       ns.research.com root.research.com. (
                                        42              ; serial (d. adams)
                                        3H              ; refresh
                                        15M             ; retry
                                        1W              ; expiry
                                        1D )            ; minimum

                NS      ns
                A       10.10.1.6
server          A       10.10.1.6
ns              A       10.10.1.6
server1         A       10.10.1.2
server2         A       10.10.1.3
server3         A       10.10.1.5
root@research:/# 
```

Figure 4.6 Configure file `/var/named/caching-examples/db.research.com`



```
root@research:/# cat /var/named/caching-example/db.10.10.1
$TTL    86400
@       IN      SOA     ns.research.com. root.research.com.  (
                                   1997022700 ; Serial
                                   28800      ; Refresh
                                   14400      ; Retry
                                   3600000    ; Expire
                                   86400 )    ; Minimum

@       IN      NS      ns.research.com.
2       IN      PTR     server1.research.com.
3       IN      PTR     server2.research.com.
5       IN      PTR     server3.research.com.
6       IN      PTR     research.com.
root@research:/# 
```

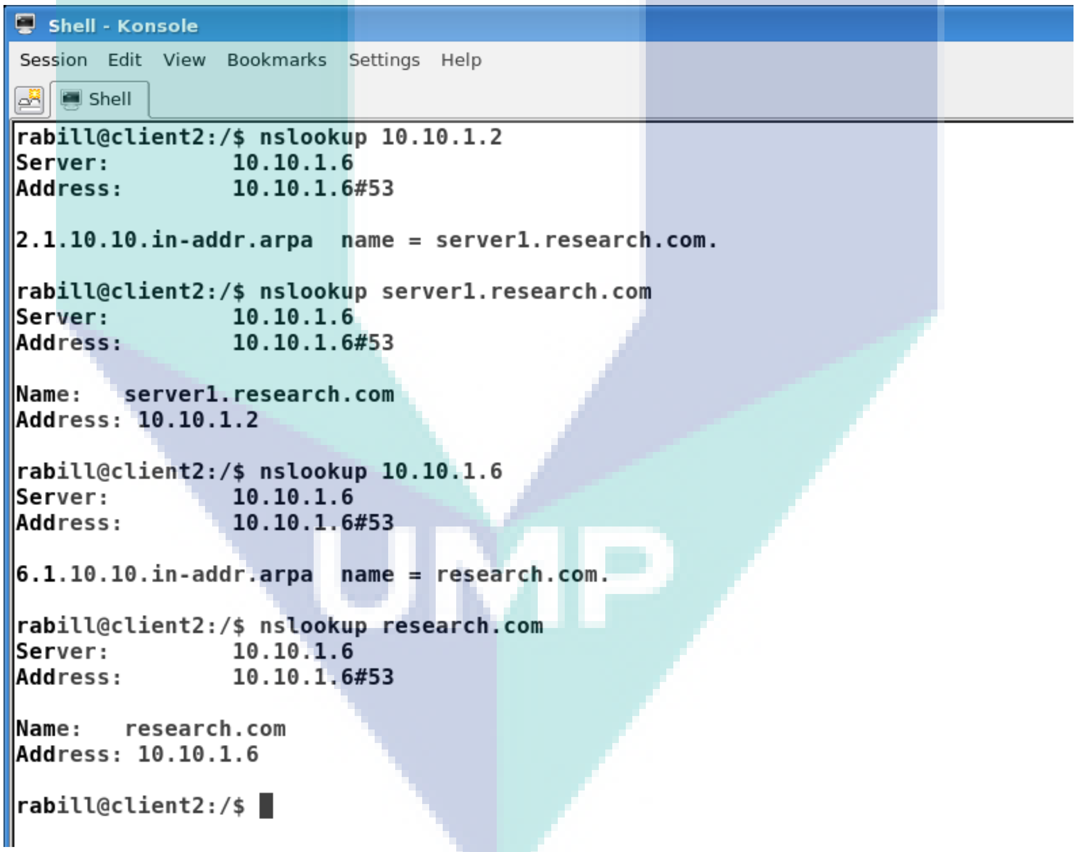
Figure 4.7 Configure file `/var/named/caching-examples/db.10.10.1`

In Figure 4.7, IP address 10.10.1.2 mapped to a domain name `server1.research.com` and for name of another server computer is shown in Table 4.6

Table 4.6 Local DNS

IP Address	DNS
10.10.1.6	research.com
10.10.1.2	server1.research.com
10.10.1.3	server2.research.com
10.10.1.5	server3.research.com

Client computer must to enter which computer is DNS server. Thats means DNS server will translate hostname to IP address and contrary IP address to hostname request from client. Settings DNS server in computer client at file `/etc/resolv.conf`. DNS server translate IP address to hostname and name to IP address are shown in Figure 4.8.



```
rabill@client2:/$ nslookup 10.10.1.2
Server:         10.10.1.6
Address:        10.10.1.6#53

2.1.10.10.in-addr.arpa  name = server1.research.com.

rabill@client2:/$ nslookup server1.research.com
Server:         10.10.1.6
Address:        10.10.1.6#53

Name:   server1.research.com
Address: 10.10.1.2

rabill@client2:/$ nslookup 10.10.1.6
Server:         10.10.1.6
Address:        10.10.1.6#53

6.1.10.10.in-addr.arpa  name = research.com.

rabill@client2:/$ nslookup research.com
Server:         10.10.1.6
Address:        10.10.1.6#53

Name:   research.com
Address: 10.10.1.6

rabill@client2:/$ █
```

Figure 4.8 Translate IP address to DNS and on the contrary

In implementation, *iptables* has been used to packet filter firewall. It works at the Network Level of the OSI model. In a firewall packet filtering phase, each network packet compared to a set of criteria. Depending on the packet and the criteria, the firewall can drop the packet, forward it or send a message to the client.

Without case of generality, this implementation uses concept that accept everything by default and drop network packets match with rules in firewall. The reason to find which one is intrusive network packet, that will then be dropped at the firewall. Therefore it accepts all the default network packet and drop the network packet intrusive.

4.2 NETWORK TRAFFIC LOGS

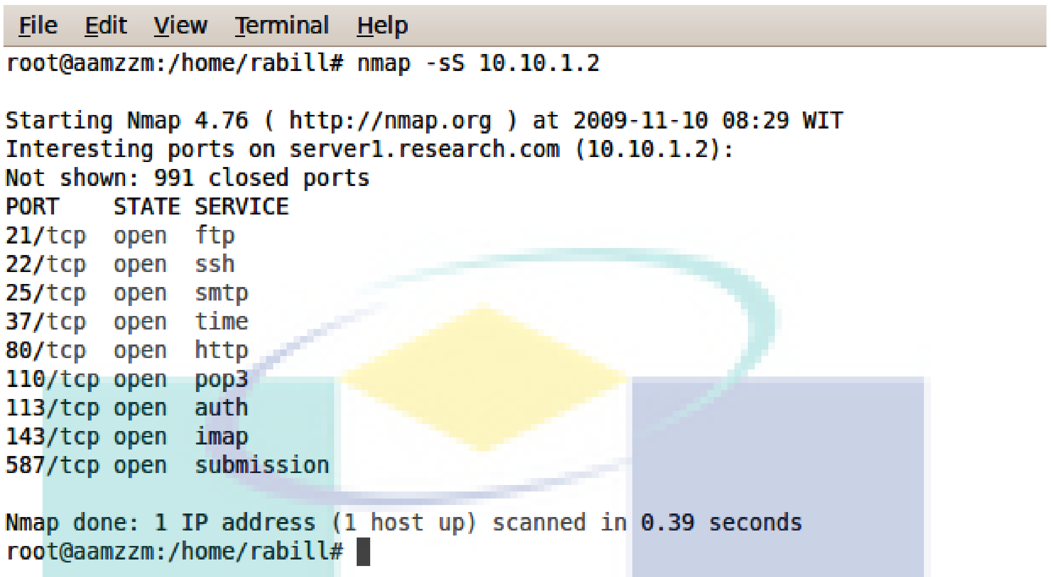
All event in the Linux OS recorded in log files. In general log files on Linux OS in the directory `/var/log/`. For example are `/var/log/syslog`, `/var/log/messages`, `/var/log/snort/alert` and others.

Snort software has been used in this implementation to see network traffics logs. *Snort* is the open source to run real-time analysis and packet logging on IP network. This software can detect various attacks and infiltration, such as buffer overflow, stealth port scans, CGI attacks, efforts of fingerprinting and others.

Snort has 3 main purposes, which are :

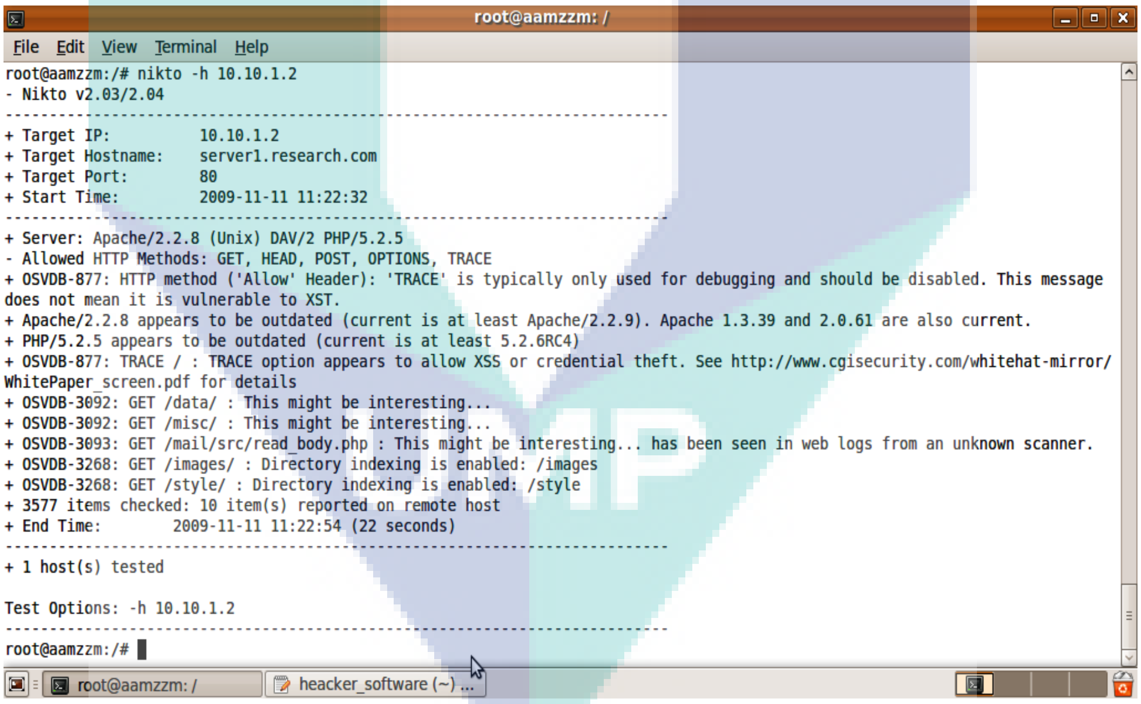
- **Sniffer mode**, to see the package through.
- **Logger mode packet**, to record all the packets through the network for later analysis.
- **Intrusion and Detection mode**, to detect attacks made through a computer network. To use this mode in IDS requires to setup a variety of rules that will distinguish normal packet with intrusion packet.

In this implementation, client computers to attack or intrusion to server computer by using some software for hackers such as nmap, nikto, tcpdump and others. For example, the attempt for intrusion is shown in Figure 4.9, 4.10 and 4.11.



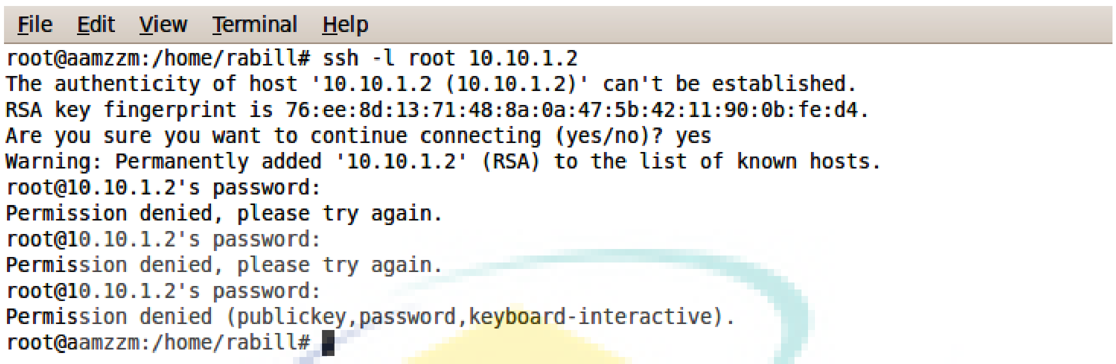
```
root@aamzzm:/home/rabill# nmap -sS 10.10.1.2

Starting Nmap 4.76 ( http://nmap.org ) at 2009-11-10 08:29 WIT
Interesting ports on server1.research.com (10.10.1.2):
Not shown: 991 closed ports
PORT     STATE SERVICE
21/tcp   open  ftp
22/tcp   open  ssh
25/tcp   open  smtp
37/tcp   open  time
80/tcp   open  http
110/tcp open  pop3
113/tcp open  auth
143/tcp open  imap
587/tcp open  submission

Nmap done: 1 IP address (1 host up) scanned in 0.39 seconds
root@aamzzm:/home/rabill#
```

Figure 4.9 *nmap* software to scan port host 10.10.1.2



```
root@aamzzm:/# nikto -h 10.10.1.2
- Nikto v2.03/2.04
---------------------------------------------------------------------------
+ Target IP:          10.10.1.2
+ Target Hostname:    server1.research.com
+ Target Port:        80
+ Start Time:         2009-11-11 11:22:32
---------------------------------------------------------------------------
+ Server: Apache/2.2.8 (Unix) DAV/2 PHP/5.2.5
- Allowed HTTP Methods: GET, HEAD, POST, OPTIONS, TRACE
+ OSVDB-877: HTTP method ('Allow' Header): 'TRACE' is typically only used for debugging and should be disabled. This message
does not mean it is vulnerable to XST.
+ Apache/2.2.8 appears to be outdated (current is at least Apache/2.2.9). Apache 1.3.39 and 2.0.61 are also current.
+ PHP/5.2.5 appears to be outdated (current is at least 5.2.6RC4)
+ OSVDB-877: TRACE / : TRACE option appears to allow XSS or credential theft. See http://www.cgisecurity.com/whitehat-mirror/
WhitePaper_screen.pdf for details
+ OSVDB-3092: GET /data/ : This might be interesting...
+ OSVDB-3092: GET /misc/ : This might be interesting...
+ OSVDB-3093: GET /mail/src/read_body.php : This might be interesting... has been seen in web logs from an unknown scanner.
+ OSVDB-3268: GET /images/ : Directory indexing is enabled: /images
+ OSVDB-3268: GET /style/ : Directory indexing is enabled: /style
+ 3577 items checked: 10 item(s) reported on remote host
+ End Time:        2009-11-11 11:22:54 (22 seconds)
---------------------------------------------------------------------------
+ 1 host(s) tested

Test Options: -h 10.10.1.2
---------------------------------------------------------------------------
root@aamzzm:/#
```

Figure 4.10 *nikto* software to get information web server at host 10.10.1.2



```
root@aamzzm:/home/rabill# ssh -l root 10.10.1.2
The authenticity of host '10.10.1.2 (10.10.1.2)' can't be established.
RSA key fingerprint is 76:ee:8d:13:71:48:8a:0a:47:5b:42:11:90:0b:fe:d4.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added '10.10.1.2' (RSA) to the list of known hosts.
root@10.10.1.2's password:
Permission denied, please try again.
root@10.10.1.2's password:
Permission denied, please try again.
root@10.10.1.2's password:
Permission denied (publickey,password,keyboard-interactive).
root@aamzzm:/home/rabill# 
```

Figure 4.11 Try to connect host 10.10.1.2 using password root failed through SSH

In *snort* software an intrusive attempt was logged on directory files in `/var/log/snort/alert` is shown on Section A of Appendix A and all of network traffics that intrusion and normal in the directory `/var/log/snort/snort.log.*` shown section B of Appendix A.

Log files intrusion activities and normal activities is shown in appendix A, retrieving data set as data training refer to Section 3.4 :

1. For the data training is intrusion, take all the data intrusion on the log files in the folder`/var/log/snort/alert`.
2. For the data training is normal, each network packet on log files in the folder `/var/log/snort/snort.log.*` will be compared with network packet is intrusion at no.1 above. If have the same source IP address, then take the network packet network is normal as training data.

Therefore there is 60 data set as data training then extracted in tabular form shown in the Table 4.7.

Table 4.7 Data set of network traffics for data training

No.	Source		Destination		Protocol	Intrusion
	IP	Port	IP	Port		
1	192.168.2.25		10.10.1.2		ICMP	Yes
2	192.168.2.25	1142	10.10.1.2	161	TCP	Yes
3	192.168.2.25	1143	10.10.1.2	162	TCP	Yes
4	192.168.2.25	1179	10.10.1.2	110	TCP	Yes
5	192.168.2.25	1175	10.10.1.2	25	TCP	Yes
6	192.168.2.25	1130	10.10.1.3	22	TCP	Yes
7	192.168.2.25	1131	10.10.1.3	22	TCP	Yes
8	192.168.2.25	1345	10.10.1.5	22	TCP	Yes
9	192.168.2.25	1347	10.10.1.5	22	TCP	Yes
10	192.168.2.25	1348	10.10.1.5	22	TCP	Yes
11	192.168.2.25	1351	10.10.1.5	22	TCP	Yes
12	192.168.2.25	1352	10.10.1.5	22	TCP	Yes
13	192.168.2.25	1356	10.10.1.5	22	TCP	Yes
14	192.168.2.25	1354	10.10.1.5	22	TCP	Yes
15	192.168.0.5		10.10.1.2		ICMP	Yes
16	192.168.0.5	1392	10.10.1.2	80	TCP	Yes
17	192.168.0.5	1394	10.10.1.2	80	TCP	Yes
18	192.168.0.5	1396	10.10.1.2	80	TCP	Yes
19	192.168.0.5	1400	10.10.1.2	80	TCP	Yes
20	192.168.0.5	1401	10.10.1.2	22	TCP	Yes
21	192.168.0.5	1405	10.10.1.2	22	TCP	Yes
22	192.168.0.5		10.10.1.3		ICMP	Yes
23	192.168.0.5	1458	10.10.1.3	80	TCP	Yes
24	192.168.0.5	1465	10.10.1.3	80	TCP	Yes
25	192.168.0.5	1463	10.10.1.3	80	TCP	Yes
26	192.168.0.5	1466	10.10.1.3	80	TCP	Yes
27	192.168.0.5	1394	10.10.1.5	22	TCP	Yes
28	192.168.0.5	1398	10.10.1.5	22	TCP	Yes
29	192.168.0.5	1402	10.10.1.5	22	TCP	Yes
30	192.168.0.5	1409	10.10.1.5	22	TCP	Yes
31	192.168.0.5	1411	10.10.1.5	22	TCP	Yes
32	192.168.0.5	1413	10.10.1.5	22	TCP	Yes
33	192.168.0.5	1181	10.10.1.3	80	TCP	No
34	192.168.0.5	1183	10.10.1.3	80	TCP	No
35	192.168.0.5	1185	10.10.1.3	80	TCP	No
36	192.168.0.5	1384	10.10.1.5	80	TCP	No
37	192.168.0.5	1391	10.10.1.5	80	TCP	No
38	192.168.0.5	1393	10.10.1.5	80	TCP	No
39	192.168.0.5	1409	10.10.1.5	80	TCP	No
40	192.168.0.5	1411	10.10.1.5	80	TCP	No
41	192.168.0.5	1413	10.10.1.5	80	TCP	No
42	192.168.1.13	1173	10.10.1.3	80	TCP	Yes
43	192.168.1.13	1175	10.10.1.3	80	TCP	Yes
44	192.168.1.13	1179	10.10.1.3	80	TCP	Yes
45	192.168.1.13	1180	10.10.1.3	80	TCP	Yes
46	192.168.1.13	1158	10.10.1.2	25	TCP	Yes
47	192.168.1.13	1203	10.10.1.3	22	TCP	No
48	192.168.1.13	1204	10.10.1.3	22	TCP	No
49	192.168.1.13	1220	10.10.1.5	22	TCP	No
50	192.168.1.13	1419	10.10.1.3	80	TCP	No
51	192.168.1.13	1423	10.10.1.3	80	TCP	No
52	192.168.2.16		10.10.1.2		ICMP	Yes
53	192.168.2.16	34592	10.10.1.2	162	TCP	Yes
54	192.168.2.16	34592	10.10.1.2	161	TCP	Yes
55	192.168.2.16	53814	10.10.1.2	3306	TCP	Yes
56	192.168.2.16	53815	10.10.1.2	3306	TCP	Yes
57	192.168.2.16	49869	10.10.1.2	80	TCP	No
58	192.168.2.16	49870	10.10.1.2	80	TCP	No
59	192.168.2.16	49871	10.10.1.2	80	TCP	No
60	192.168.2.16	49872	10.10.1.2	80	TCP	No

4.3 CONSTRUCT DECISION TREE USING ID3 ALGORITHM

Based on the network traffics shown in Table 4.7, there are two conditions that must be followed in building a decision tree :

1. The value of the source port attribute so many, there 60 value in source port attribute where the value is different each other. This causes the value of *entropy* of the source port is 0 based on Equation (3.3) in section 3.4.2:

$$E(S,A) = \sum_{v \in Value(A)} \frac{|S_v|}{|S|} E(S_v)$$

$$\begin{aligned} E(\text{Intrusion,Source Port}) &= 1/60\,(-1/1 \log_2 1/1 - 0/1 \log_2 0/1) \\ &\quad + 1/60\,(-1/1 \log_2 1/1 - 0/1 \log_2 0/1) \\ &\quad + \ldots + 1/60\,(-1/1 \log_2 1/1 - 0/1 \log_2 0/1) \\ &= 0 + 0 + 0 + \ldots +0 \\ &= 0 \end{aligned}$$

and value of *gain* is always high based on Equation (3.4) in section 3.4.2:

$$\begin{aligned} \text{Gain}(S,A) &= E(S) - E(S,A) \\ G(\text{Intrusion, Source IP}) &= E(\text{Intrusion}) - E(\text{Intrusion, Source IP}) \\ &= E(\text{Intrusion}) - 0 \end{aligned}$$

Consequently source port attribute always as root node. If the source port attribute as root node decision tree classification is not useful anymore, because under source port of the node is the all value of source port attribute. Therefore, the source port is ignored calculations to construct decision tree. Source port is used as the last node if all attribute has become nodes in the tree, then the last options is the source port attribute as a node.

2. Source port and destination port cannot implemented into firewall rules without protocol. Figure 4.12 show an example of rules is wrong.

```
R1   :  -A FORWARD --dport 22 -j DROP
R2   :  -A FORWARD --sport 1890 -j DROP
R3   :  -A FORWARD --sport 1890 –dport 22 –j DROP
```

Figure 4.12. The description of the wrong rules in firewall

Source Port and Destination Port need Protocol to create rules into firewall. Therefore, Protocol and Destination Port become one attribute for calculate *Entropy* and *Gain*. To construct decision tree Protocol attribute as node for first follow is Destination Port.

The first step to find attributes at the top of tree as root node from data set is shown in Table 4.7, there is 60 data sets where 42 intrusion and 18 normal.

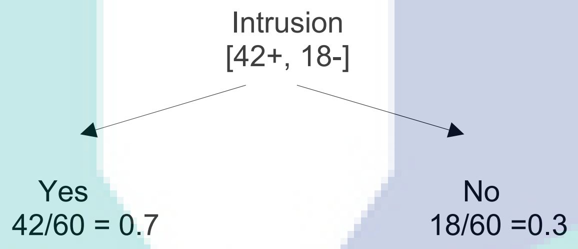


Figure 4.13 The set of 60 examples where 42 intrusion and 18 normal

To Calculate entropy of Intrusion is based on Equation (3.1) in Section 3.4.1:

$$
\begin{aligned}
E(S) &= -p_{+} \log_2(p_{+}) - p_{-} \log_2(p_{-}) \\
E(\text{Intrusion}) &= -42/60 \log_2(42/60) - 18/60 \log_2(18/60) \\
&= 0.7 \log_2 0.7 - 0.3 \log_2 0.3 \\
&= 0.8813
\end{aligned}
$$

The next step to calculate for each of attributes.

In Table 4.7 there are four values from the Source IP. Every value of the Source IP is counted in order to know how many intrusion and not intrusion. To more easily make in the form of tables. An example in Table 4.8 is described the value of the Source IP attribute.

Table 4.8 Source IP

Source IP	Intrusion		Sum
	Yes	No	
192.168.2.25	14	0	14
192.168.0.5	18	9	27
192.168.1.13	5	5	10
192.168.2.16	5	4	9
		Sum	60

To Calculate entropy Intrusion of Source IP based on Equation (3.3) in Section 3.4.2.

$$E(S,A) = \sum_{v \in Value(A)} \frac{|S_v|}{|S|} E(S_v)$$

$$\begin{aligned}
\text{E(Intrusion,Source IP)} &= 14/60\ (-14/14 \log_2 14/60 - 0/14 \log_2 0/14) \\
&\quad + 27/60\ (-18/27 \log_2 18/27 - 9/27 \log_2 9/27) \\
&\quad + 15/60\ (-5/10 \log_2 5/10 - 5/10 \log_2 5/10) \\
&\quad + 9/60\ (-5/9 \log_2 5/9 - 4/9 \log_2 4/9) \\
&= 0 + 0.4132 + 0.1666 + 0.1487 \\
&= 0.7285
\end{aligned}$$

To calculate gain Intrusion of Source IP based on Equation (3.4) in Section 3.4.2.

$$\begin{aligned}
\text{Gain(S,A)} &= \text{E(S)} - \text{E(S,A)} \\
\text{G(Intrusion, Source IP)} &= \text{E(Intrusion)} - \text{E(Intrusion, Source IP)} \\
&\quad 0.8813 - 0.7285 \\
&= 0.1528
\end{aligned}$$

To calculate entropy and gain Intrusion of Destination IP:

In Table 4.7 there are four values from the Destination IP. Every value of the Destination IP is counted how many intrusion and not intrusion. This Procedure was conducted to define the value of every attribute. In Table 4.8 is described the value of the Source IP attribute.

Table 4.9 Destination IP

Destination IP	Intrusion		Sum
	Yes	No	
10.10.1.2	18	4	22
10.10.1.3	11	7	18
10.10.1.5	13	7	20
		Sum	60

To Calculate entropy Intrusion of Destination IP based on Equation (3.3) in Section 3.4.2.

$$E(S,A) = \sum_{v \in Value(A)} \frac{|S_v|}{|S|} E(S_v)$$

$$\begin{aligned}\text{E(Intrusion, Destination IP)} &= 22/60\ (-18/22 \log_2 18/22 - 4/22 \log_2 4/22) \\ &\quad + 18/60\ (-11/18 \log_2 11/18 - 7/18 \log_2 7/18) \\ &\quad + 20/60\ (-13/20 \log_2 13/20 - 7/20 \log_2 7/20) \\ &= 0.25 + 0.2892 + 0.3114 \\ &= 0.8506\end{aligned}$$

To calculate gain Intrusion of Destination IP based on Equation (3.4) in Section 3.4.2.

$$\begin{aligned}\text{Gain(S,A)} &= \text{E(S)} - \text{E(S,A)} \\ \text{G(Intrusion, Destination IP)} &= \text{E(Intrusion)} - \text{E(Intrusion, Destination IP)} \\ \text{G(Intrusion, Destination IP)} &= 0.8813 - 0.8506 \\ &\quad 0.0307\end{aligned}$$

To calculate entropy and gain Intrusion of Protocol and Destination Port attribute:

Table 4.10 Protocol and Destination Port

Protocol & Destination Port		Intrusion		Sum
		Yes	No	
ICMP		4	0	4
TCP	22	17	3	20
TCP	25	2	0	2
TCP	80	12	15	27
TCP	110	1	0	1
TCP	161	2	0	2
TCP	162	2	0	2
TCP	3360	2	0	2
			Sum	60

To Calculate entropy Intrusion of Protocol and Destination Port based on Equation (3.3) in Section 3.4.2.

$$E(S,A) = \sum_{v \in Value(A)} \frac{|S_v|}{|S|} E(S_v)$$

$$\begin{aligned}
E(\text{Intrusion, Protocol \& Dest Port}) &= 4/60\,(-4/4 \log_2 4/4 - 0/4 \log_2 0/4)\\
&+ 20/60\,(-17/20 \log_2 17/20 - 3/20 \log_2 3/20)\\
&+ 2/60\,(-2/2 \log_2 2/2 - 0/2 \log_2 0/2)\\
&+ 27/60\,(-12/27 \log_2 12/27 - 15/27 \log_2 15/27)\\
&+ 1/60\,(-1/1 \log_2 1/1 - 0/1 \log_2 0/1)\\
&+ 2/60\,(-2/2 \log_2 2/2 - 0/2 \log_2 0/2)\\
&+ 2/60\,(-2/2 \log_2 2/2 - 0/2 \log_2 0/2)\\
&+ 2/60\,(-2/2 \log_2 2/2 - 0/2 \log_2 0/2)\\
&= 0 + 0.2033 + 0 + 0.4460 + 0 + 0 + 0 + 0\\
&= 0.6493
\end{aligned}$$

To calculate gain Intrusion of Protocol and Destination Port based on Equation (3.4) in Section 3.4.2.

$$\text{Gain}(S,A) = E(S) - E(S,A)$$

$$G(\text{Intrusion, Protocol \& Dest Port}) = E(\text{Intrusion}) - E(\text{Intrusion, Protocol \& Dest Port})$$

$$\begin{aligned}
G(\text{Intrusion, Protocol \& Dest Port}) &= 0.8813 - 0.6493\\
&= 0.2320
\end{aligned}$$

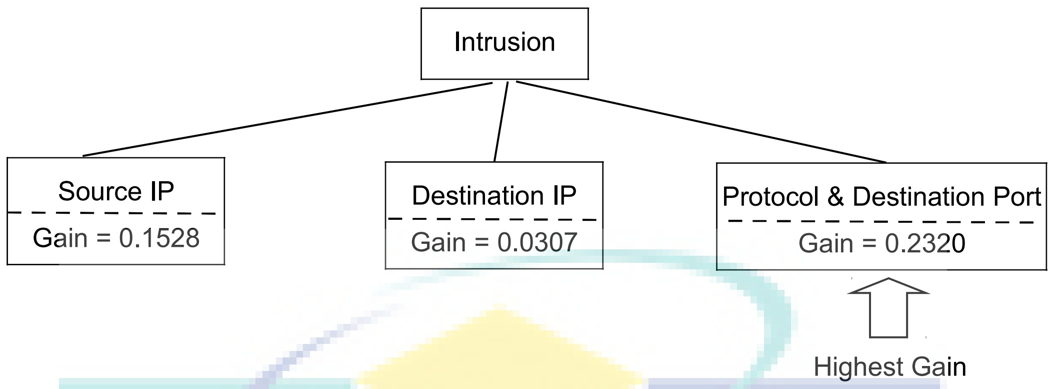


Figure 4.14 Each Gain of attributes

The highest **Gain** in Figure 4.14 is Protocol and Destination Port attribute which value is 0.2320. Therefore, Protocol and Destination Port attribute is used as root node which shown in Figure 4.15.

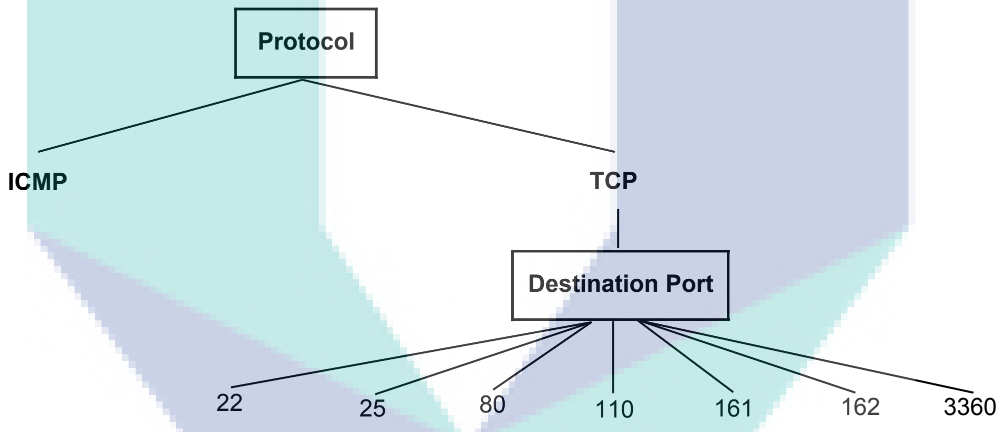


Figure 4.15 Protocol and Destination Port as root node

Separate the attribute protocol and destination port become two parts. The first attribute is Protocol that has the value is ICMP and TCP. Then follow the Destination Port attribute is shown in Figure 4.15. Now define the following attributes under the ICMP protocol.

To calculate Gain for each attribute use Protocol = ICMP:

These instances that use Protocol = ICMP as shown in Table 4.11.

Table 4.11 All data set using Protocol = ICMP

No.	Source		Destination		Protocol	Intrusion
	IP	Port	IP	Port		
1	192.168.2.25		10.10.1.2		ICMP	Yes
2	192.168.0.5		10.10.1.2		ICMP	Yes
3	192.168.0.5		10.10.1.3		ICMP	Yes
4	192.168.2.16		10.10.1.2		ICMP	Yes

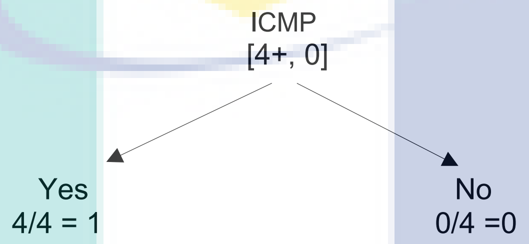


Figure 4.16 The set of 4 examples Protocol = ICMP are 4 intrusion and 0 normal

To calculate entropy of Protocol = ICMP based on Equation (3.1) in Section 3.4.1:

$$\begin{aligned} E\,(S) &= -p_{+} \log_2(p_{+}) - p_{-} \log_2(p_{-}) \\ E\,(\text{ICMP}) &= -\,4/4 \log_2 (4/4) - 0/4 \log_2 (0/4) \\ &= 0 \end{aligned}$$

From the above calculation, *E* (ICMP) is equals to 0 This shows that the incident was pure impurity is 'Yes' and can be described in decision tree as shown in Figure 4.17.

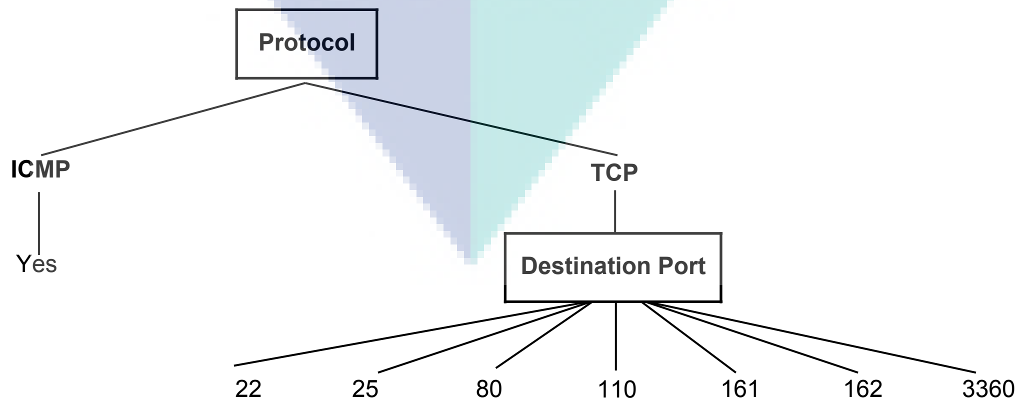


Figure 4.17 All of instance of ICMP Protocol is Intrusion = Yes

Next, to find and define the next attribute under the Protocol = TCP and Destination Port = 22.

To calculate Gain for each attributes using Protocol = TCP and Destination = 22 attribute. All of instances (see in Table 4.7) which using attribute Protocol = TCP and Destination Port = 22 is shown in Table 2.12.

Table 4.12 All data set using Protocol = TCP and Destination Port = 22

No.	Source		Destination		Protocol	Intrusion
	IP	Port	IP	Port		
1	192.168.2.25	1130	10.10.1.3	22	TCP	Yes
2	192.168.2.25	1131	10.10.1.3	22	TCP	Yes
3	192.168.2.25	1345	10.10.1.5	22	TCP	Yes
4	192.168.2.25	1347	10.10.1.5	22	TCP	Yes
5	192.168.2.25	1348	10.10.1.5	22	TCP	Yes
6	192.168.2.25	1351	10.10.1.5	22	TCP	Yes
7	192.168.2.25	1352	10.10.1.5	22	TCP	Yes
8	192.168.2.25	1356	10.10.1.5	22	TCP	Yes
9	192.168.2.25	1354	10.10.1.5	22	TCP	Yes
10	192.168.0.5	1401	10.10.1.2	22	TCP	Yes
11	192.168.0.5	1405	10.10.1.2	22	TCP	Yes
12	192.168.0.5	1394	10.10.1.5	22	TCP	Yes
13	192.168.0.5	1398	10.10.1.5	22	TCP	Yes
14	192.168.0.5	1400	10.10.1.5	22	TCP	Yes
15	192.168.0.5	1409	10.10.1.5	22	TCP	Yes
16	192.168.0.5	1411	10.10.1.5	22	TCP	Yes
17	192.168.0.5	1413	10.10.1.5	22	TCP	Yes
18	192.168.1.13	1203	10.10.1.3	22	TCP	No
19	192.168.1.13	1204	10.10.1.3	22	TCP	No
20	192.168.1.13	1220	10.10.1.5	22	TCP	No

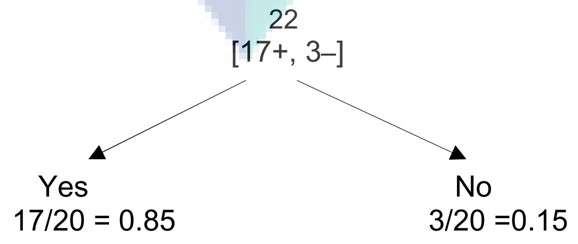


Figure 4.18 The set of 20 examples Dest Port=22 are 17 intrusion and 3 normal

To calculate entropy of Destination Port = 22 based on Equation (3.1) in Section 3.4.1:

$$E(S) = -p_+ \log_2(p_+) - p_- \log_2(p_-)$$

$$E(22) = -17/20 \log_2 (17/20) - 3/20 \log_2 (3/20)$$
$$= 0.85 \log_2 0.85 - 0.15 \log_2 0.15$$
$$= 0.6098$$

To calculate each entropy and Gain attributes are Source IP and Destination IP:

✓ Entropy and Gain Destination Port = 22 attribute of Source IP

Table 4.13 Source IP using Protocol = TCP and Destination Port = 22

Source IP	Intrusion		Sum
	Yes	No	
192.168.2.25	9	0	9
192.168.0.5	8	9	8
192.168.1.13	0	3	3
		Sum	20

To calculate entropy Destination Port = 22 of source IP based on Equation (3.3) in Section 3.4.2.

$$E(S,A) = \sum_{v \in Value(A)} \frac{|S_v|}{|S|} E(S_v)$$

$$E(S_{22}, \text{Source IP}) = 9/20 (-9/9 \log_2 9/9 - 0/9 \log_2 0/9)$$
$$+ 8/20 (-8/8 \log_2 8/8 - 0/8 \log_2 0/8)$$
$$+ 3/20 (-0/3 \log_2 0/3 - 3/3 \log_2 3/0)$$
$$= 0$$

To calculate gain of Source IP based on Equation (3.4) in Section 3.4.2.

$$\text{Gain}(S,A) = E(S) - E(S,A)$$
$$G(S_{22}, \text{Source IP}) = E(22) - E(S_{22}, \text{Source IP})$$
$$G(S_{22}, \text{Source IP}) = 0.6098 - 0$$
$$= 0.6098$$

✓ Entropy and Gain Destination Port = 22 of Destination IP

Table 4.14 Destination IP using Destination Port = 22

Destination IP	Intrusion		Sum
	Yes	No	
10.10.1.2	2	0	2
10.10.1.3	2	2	4
10.10.1.5	13	1	14
		Sum	20

To calculate entropy Destination Port =22 of Destination IP based on Equation (3.3) in Section 3.4.2.

$$E(S,A) = \sum_{v \in Value(A)} \frac{|S_v|}{|S|} E(S_v)$$

$$\begin{aligned} E(S_{22}, \text{Destination IP}) &= 2/20\,(-2/2 \log_2 2/2 - 0/2 \log_2 0/2) \\ &\quad + 4/20\,(-2/4 \log_2 2/4 - 2/4 \log_2 2/4) \\ &\quad + 14/20\,(-13/20 \log_2 13/20 - 1/14 \log_2 1/14) \\ &= 0 + 0.2 + 0.2599 \\ &= 0.4599 \end{aligned}$$

Calculate gain Destination Port =22 of Destination IP based on Equation (3.4) in Section 3.4.2

$$\begin{aligned} \text{Gain}(S,A) &= E(S) - E(S,A) \\ G(S_{22}, \text{Destination IP}) &= E(22) - E(S_{22}, \text{Destination IP}) \\ G(S_{22}, \text{Destination IP}) &= 0.6098 - 0.4599 \\ & 0.1499 \end{aligned}$$

Source IP has the highest **Gain.** Therefore, Source IP used as the decision node under Protocol = TCP and Destination Port = 22 which shown in Figure 4.19.

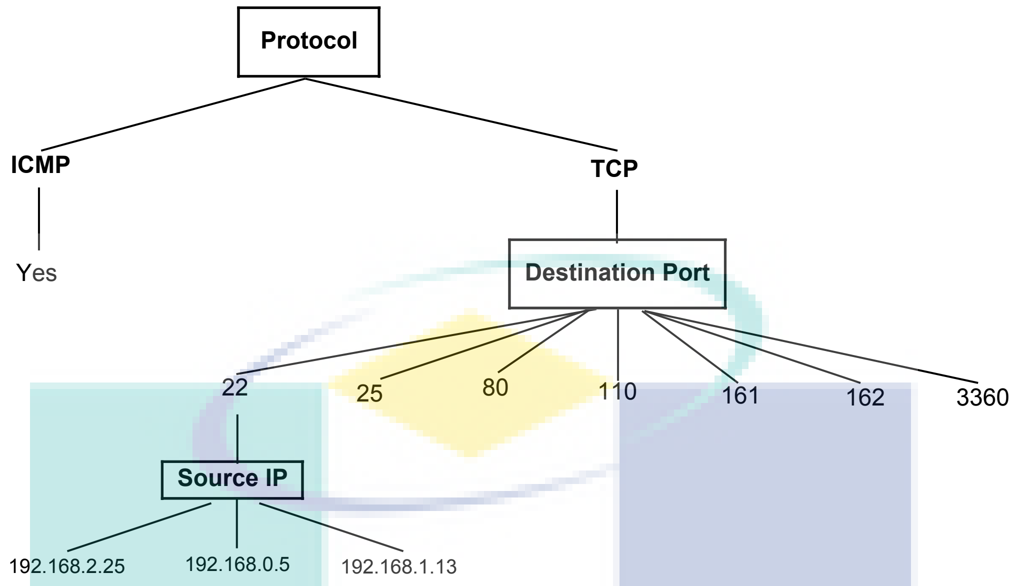


Figure 4.19 Source IP decision node under Destination Port = 22

The next step to find node under Protocol=TCP, Destination Port=22 and Source IP = 192.168.2.25. To calculate Gain for each attributes use Protocol=TCP, Destination Port=22 and Source IP = 192.168.2.25

Table 4.15 Protocol = TCP, Source IP = 192.168.2.25 and Destination Port = 22

No.	Source		Destination		Protocol	Intrusion
	IP	Port	IP	Port		
1	192.168.2.25	1130	10.10.1.3	22	TCP	Yes
2	192.168.2.25	1131	10.10.1.3	22	TCP	Yes
3	192.168.2.25	1345	10.10.1.5	22	TCP	Yes
4	192.168.2.25	1347	10.10.1.5	22	TCP	Yes
5	192.168.2.25	1348	10.10.1.5	22	TCP	Yes
6	192.168.2.25	1351	10.10.1.5	22	TCP	Yes
7	192.168.2.25	1352	10.10.1.5	22	TCP	Yes
8	192.168.2.25	1356	10.10.1.5	22	TCP	Yes
9	192.168.2.25	1354	10.10.1.5	22	TCP	Yes

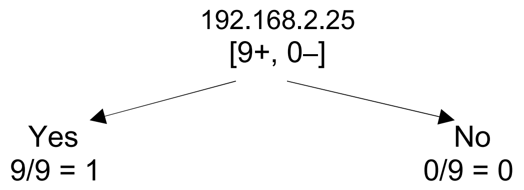


Figure 4.20 The set of 20 examples Source Port =22 are 17 intrusion and 3 normal

$$E(S) = -p_{+} \log_2(p_{+}) - p_{-} \log_2(p_{-})$$
$$E(192.168.0.25) = -9/9 \log_2(9/9) - 0/9 \log_2(0/9)$$
$$= 0$$

From the calculation above, *E* (192.168.0.25) is equal 0. This is pure impurity. That is all occurrences using Protocol=TCP, Destination Port = 22 and Source IP =192.168.2.25 is Intrusion ='Yes'. For another is same, *E*(192.168.0.5) is equal to 0 and *E*(192.168.0.13) is equal to 0. Therefore, decision tree is shown in Figure 4.21.

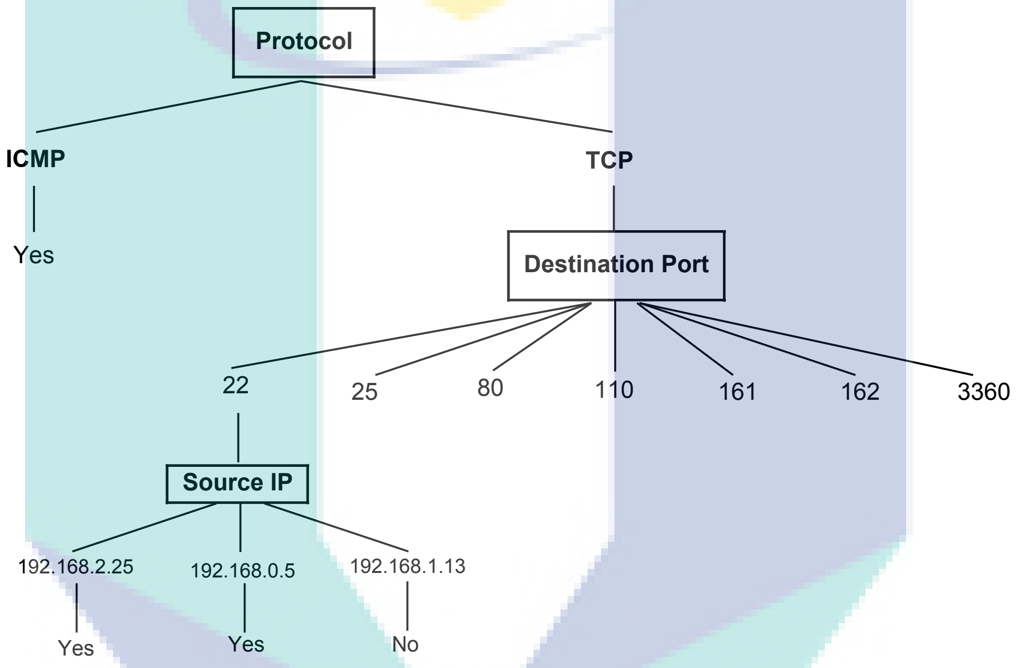


Figure 4.21 Leaf node Protocol = TCP and Destination Port = 22

This process goes on until all data classified perfectly or run out of attributes. The complete of tree is shown in Figure 4.22. Decision tree can simplified by pruning all connections to normal and not classified is shown in Figure 4.23.

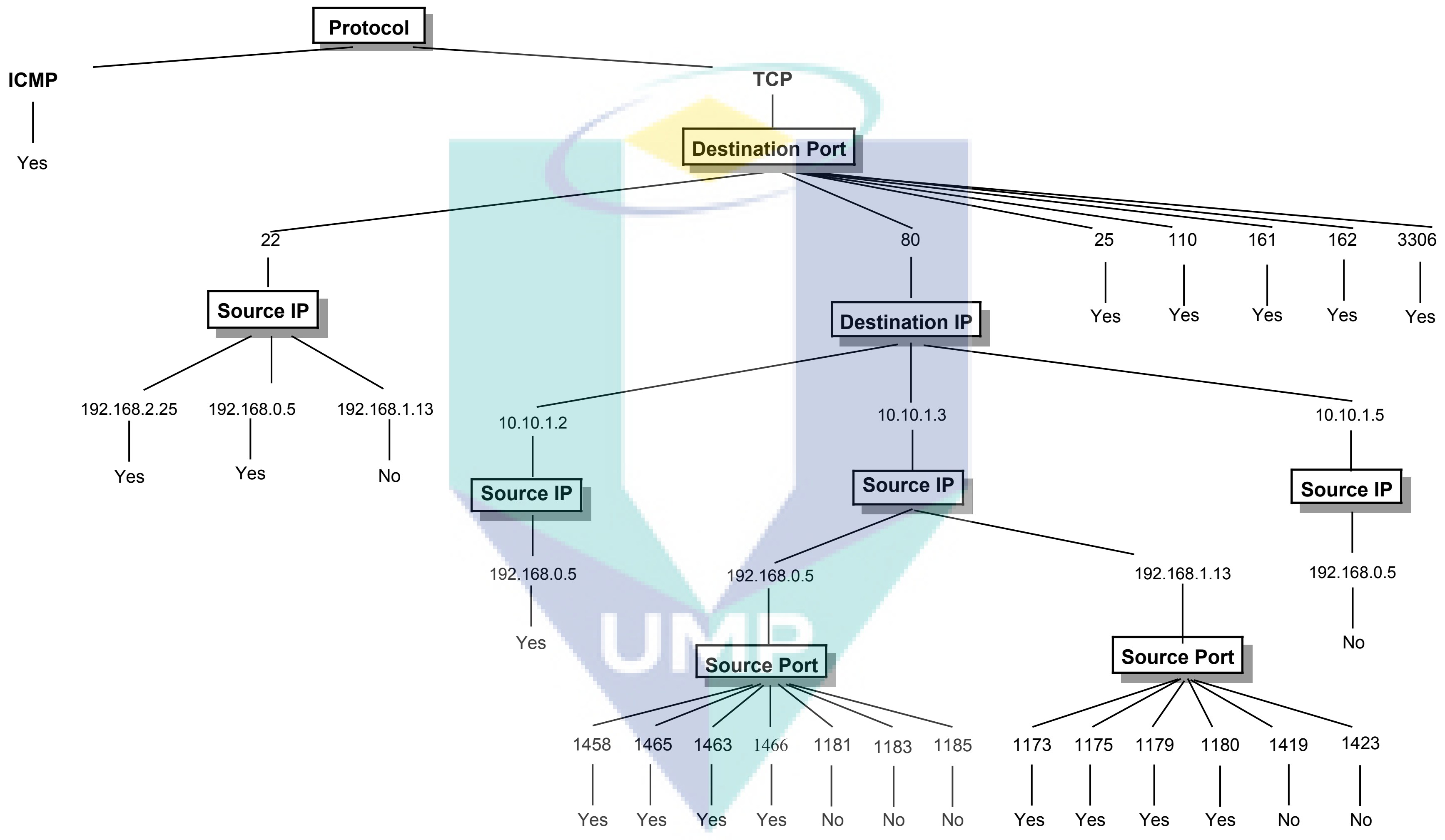


Figure 4.22 Complete decision tree network traffics

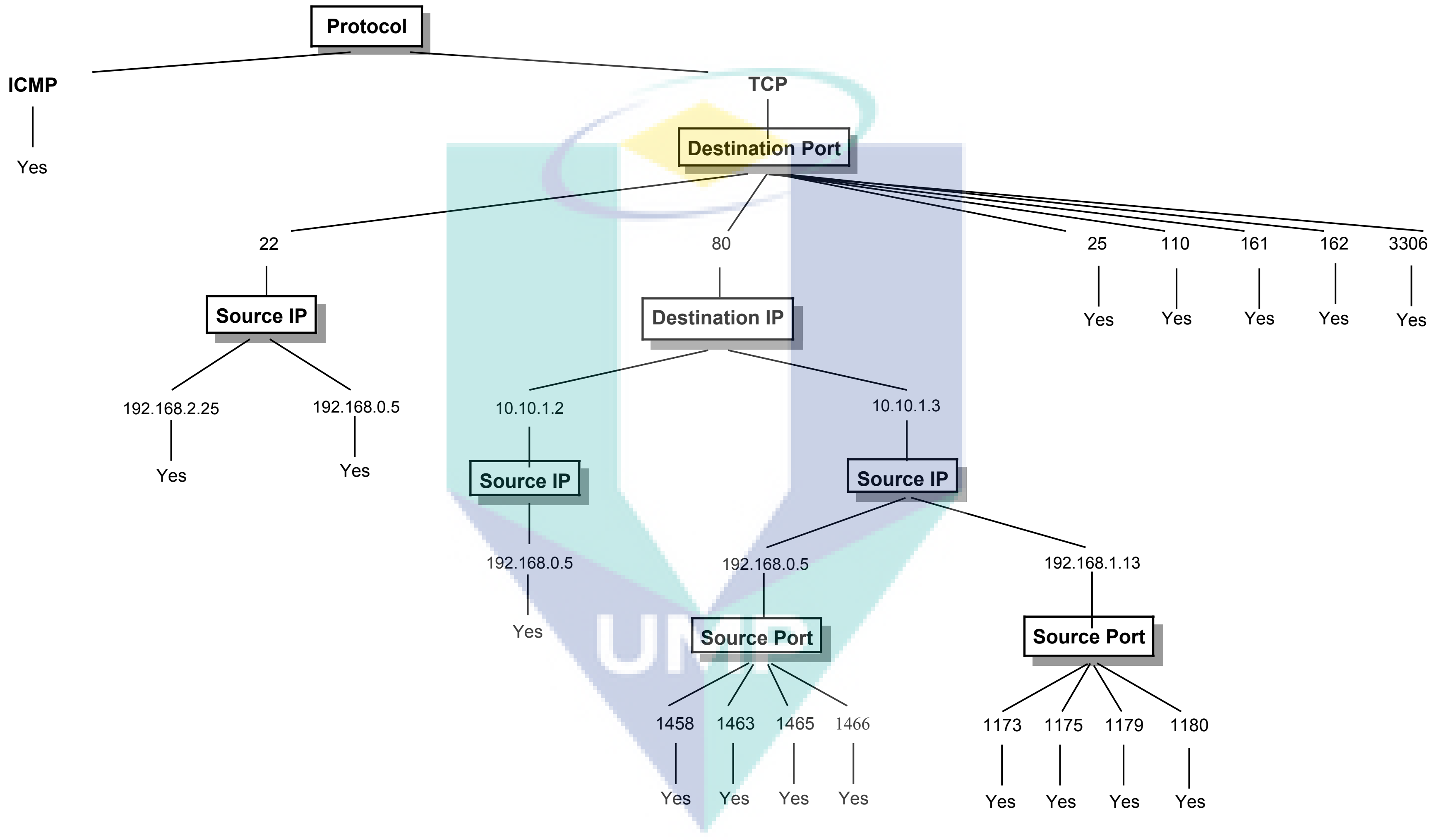


Figure 4.23 Pruning decision tree network traffics

4.4 RULE EXTRACTION IF-THEN

The knowledge represented in decision trees can to extracted and represented in the form of IF-THEN rules. One rule created for each path from the root to a leaf node. Each attribute-value pair along a given path forms a conjunction in the rule antecedent ("IF" part). The leaf node holds the class prediction, forming the rule consequent ("THEN" part). The IF-THEN rules may be easier than decision tree for humans to understand. Decision tree in shown Figure 4.23 have been extracted in the form IF-THEN as shown Figure 4.24.

R1 : IF (Protocol = ICMP) THEN Intrusion = Yes

R2 : IF (Protocolt = TCP) AND (Dest Prot = 22) AND (Source IP=192.168.2.25)
THEN Intrusion = Yes

R3 : IF (Protocolt = TCP) AND (Dest Prot = 22) AND (Source IP = 192.168.0.5)
THEN Intrusion = Yes

R4 : IF (Protocol = TCP) AND (Dest Port = 80) AND (Dest IP = 10.10.1.2) AND
(Source IP = 192.168.0.5) THEN Intrusion = Yes

R5 : IF (Protocol = TCP) AND (Dest Port = 80) AND (Dest IP = 10.10.1.2) AND
(Source IP = 192.168.2.16) THEN Intrusion = Yes

R6 : IF (Protocol = TCP) AND (Dest Port = 80) AND (Dest IP = 10.10.1.3) AND
(Source IP = 192.168.0.5) AND (Source Port = 1458) THEN Intrusion = Yes

R7 : IF (Protocol = TCP) AND (Dest Port = 80) AND (Dest IP = 10.10.1.3) AND
(Source IP = 192.168.0.5) AND (Source Port = 1463) THEN Intrusion = Yes

R8 : IF (Protocol = TCP) AND (Dest Port = 80) AND (Dest IP = 10.10.1.3) AND
(Source IP = 192.168.0.5) AND (Source Port = 1465) THEN Intrusion = Yes

R9 : IF (Protocol = TCP) AND (Dest Port = 80) AND (Dest IP = 10.10.1.3) AND
(Source IP = 192.168.0.5) AND (Source Port = 1466) THEN Intrusion = Yes

R10 : IF (Protocol = TCP) AND (Dest Port = 80) AND (Dest IP = 10.10.1.3) AND
(Source IP = 192.168.1.13) AND (Source Port = 1173) THEN Intrusion = Yes

R11 : IF (Protocol = TCP) AND (Dest Port = 80) AND (Dest IP = 10.10.1.3) AND
(Source IP = 192.168.1.13) AND (Source Port = 1175) THEN Intrusion = Yes

R12 : IF (Protocol = TCP) AND (Dest Port = 80) AND (Dest IP = 10.10.1.3) AND
(Source IP = 192.168.1.13) AND (Source Port = 1179) THEN Intrusion = Yes

R13 : IF (Protocol = TCP) AND (Dest Port = 80) AND (Dest IP = 10.10.1.3) AND
(Source IP = 192.168.1.13) AND (Source Port = 1180) THEN Intrusion = Yes

R14 : IF (Protocol = TCP) AND (Dest Port = 25) THEN Intrusion = Yes

R15 : IF (Protocol = TCP) AND (Dest Port = 110) THEN Intrusion = Yes

R16 : IF (Protocol = TCP) AND (Dest Port = 161) THEN Intrusion = Yes

R17 : IF (Protocol = TCP) AND (Dest Port = 162) THEN Intrusion = Yes

R18 : IF (Protocol = TCP) AND (Dest Port = 3306) THEN Intrusion = Yes

Figure 4.24 Rules extraction to IF-THEN

4.5 CLASSIFICATION INTRUSION OR NORMAL OF THE NEW NETWORK PACKET

The example of extract rules of tree decision (see Figure 4.24) is rules of intrusion . Every network packet will be checked with these rules one by one. If there is one of the rules contained in a network packet, the network packet is intrusion. This called the IDS, the network can determine the packet is intrusion or not. For illustration, given new network traffics as show in Table 4.16.

Table 4.16 The new network traffics

No.	Source		Destination		Protocol	Intrusion
	IP	Port	IP	Port		
1	192.168.2.25	1430	10.10.1.3	22	TCP	?
2	192.168.0.5	1557	10.10.1.3	80	TCP	?
3	192.168.0.5	1622	10.10.1.2	80	TCP	?
4	192.168.1.4	1647	10.10.1.5	22	TCP	?
5	192.168.1.13	1185	10.10.1.2	80	TCP	?
6	192.168.0.5	1500	10.10.1.2	80	TCP	?
7	192.168.0.2	1352	10.10.1.5	3306	TCP	?
8	192.168.2.25	1356	10.10.1.5	22	TCP	?
9	192.168.2.20	1890	10.10.1.5	80	TCP	?

The rules based on the results of the training set of network traffics can to predictive the new network traffics is intrusion activities or normal activities. Table 4.17 shows to predictive the new network traffics is intrusion activities or normal activities.

Table 4.17 To predict new network traffics

No.	Source		Destination		Protocol	Intrusion
	IP	Port	IP	Port		
1	192.168.2.25	1430	10.10.1.3	22	TCP	Yes
2	192.168.0.5	1557	10.10.1.3	80	TCP	No
3	192.168.0.5	1622	10.10.1.2	80	TCP	Yes
4	192.168.1.4	1647	10.10.1.5	22	TCP	No
5	192.168.1.13	1185	10.10.1.2	80	TCP	No
6	192.168.0.5	1500	10.10.1.2	80	TCP	Yes
7	192.168.0.2	1352	10.10.1.5	3306	TCP	Yes
8	192.168.2.25	1356	10.10.1.5	22	TCP	Yes
9	192.168.2.20	1890	10.10.1.5	80	TCP	No

Consider a case for network traffic in line 1. This network packet is intrusion, because network traffic in line 1 have subset characteristics of R2. (see Figure 4.24). Because on R2 everything network packet has Protocol = TCP, Destination Port = 22 and source IP = 192.168.2.25 is intrusion. These characters belong line 1 in Table 4.17.

For another example, consider network traffics in line 6. This network packet is intrusion, because network traffic in line 6 have subset characteristics of R4. Because in R4 everything network packet has Protocol = TCP, Destination Port = 80, Destination IP = 10.10.1.2 and source IP = 192.168.0.5 is intrusion. These characters belong line 6 in Table 4.17.

4.6 IMPLEMENTATION RULES OF INTRUSION SIGNATURE INTO FIREWALL RULES

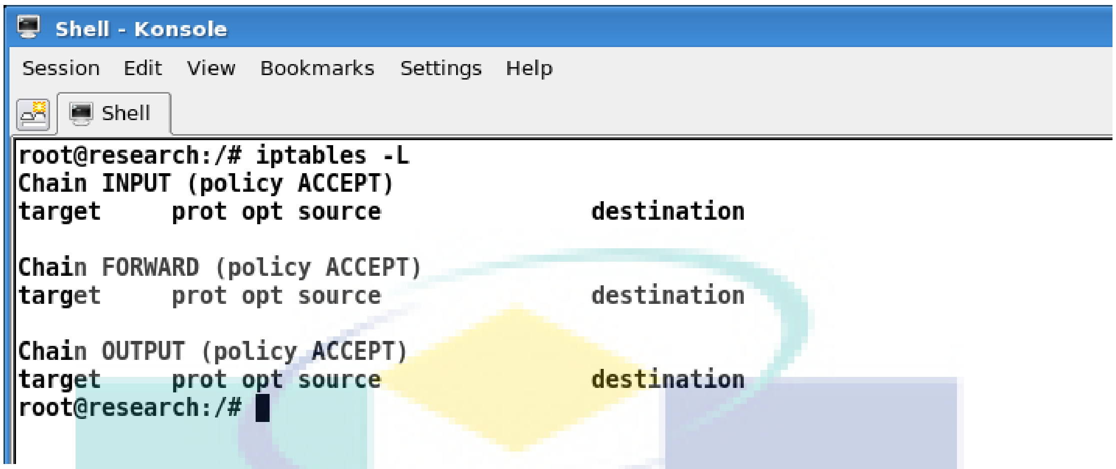
Rules of intrusion implemented in firewall rules for prevention, where every network packet have rules of intrusion signature will drop. The network packet cannot allow to go through a firewall machine. The rules of intrusion signature implemented firewall rules is shown in Figure 4.25.

```
R1   :  -A FORWARD -p icmp -j DROP
R2   :  -A FORWARD -p tcp -s 192.168.2.25 --dport 22 -j DROP
R3   :  -A FORWARD -p tcp -s 192.168.0.5 --dport 22 -j DROP
R4   :  -A FORWARD -p tcp -s 192.168.0.5 -d 10.10.1.2 --dport 80 -j DROP
R5   :  -A FORWARD -p tcp -s 192.168.0.5 --sport 1458 -d 10.10.1.3 --dport 80 -j DROP
R6   :  -A FORWARD -p tcp -s 192.168.0.5 --sport 1463 -d 10.10.1.3 --dport 80 -j DROP
R7   :  -A FORWARD -p tcp -s 192.168.0.5 --sport 1465 -d 10.10.1.3 --dport 80 -j DROP
R8   :  -A FORWARD -p tcp -s 192.168.0.5 --sport 1466 -d 10.10.1.3 --dport 80 -j DROP
R9   :  -A FORWARD -p tcp -s 192.168.1.13 --sport 1173 -d 10.10.1.3 --dport 80 -j DROP
R10  :  -A FORWARD -p tcp -s 192.168.1.13 --sport 1175 -d 10.10.1.3 --dport 80 -j DROP
R11  :  -A FORWARD -p tcp -s 192.168.1.13 --sport 1179 -d 10.10.1.3 --dport 80 -j DROP
R12  :  -A FORWARD -p tcp -s 192.168.1.13 --sport 1180 -d 10.10.1.3 --dport 80 -j DROP
R13  :  -A FORWARD -p tcp --dport 25 -j DROP
R14  :  -A FORWARD -p tcp --dport 110 -j DROP
R15  :  -A FORWARD -p tcp --dport 161 -j DROP
R16  :  -A FORWARD -p tcp --dport 162 -j DROP
R17  :  -A FORWARD -p tcp --dport 3306 -j DROP
```

Figure 4.25. Rules of intrusion implemented into firewall rules

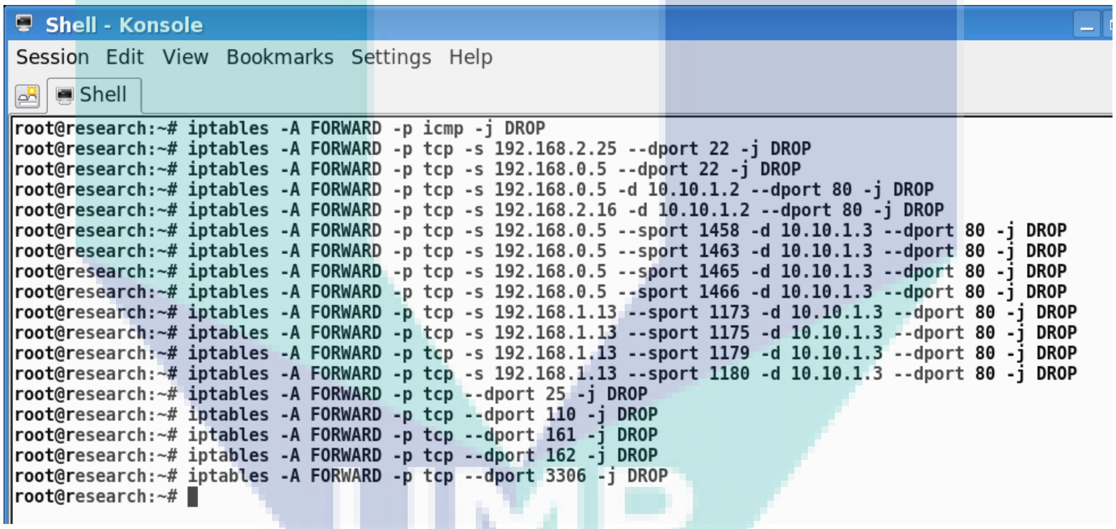
Researcher uses the command 'FORWARD' because firewall rules above will be implemented in machine as the router will forward packets from outgoing to incoming LAN. Each packet network must be checked against the rules established by firewall, if the rules match the firewall will drop the network packet.

Rules of intrusion to be implemented into *iptables* firewall Linux are shown in Figure 4.26, Figure 4.27 and Figure 4.28.



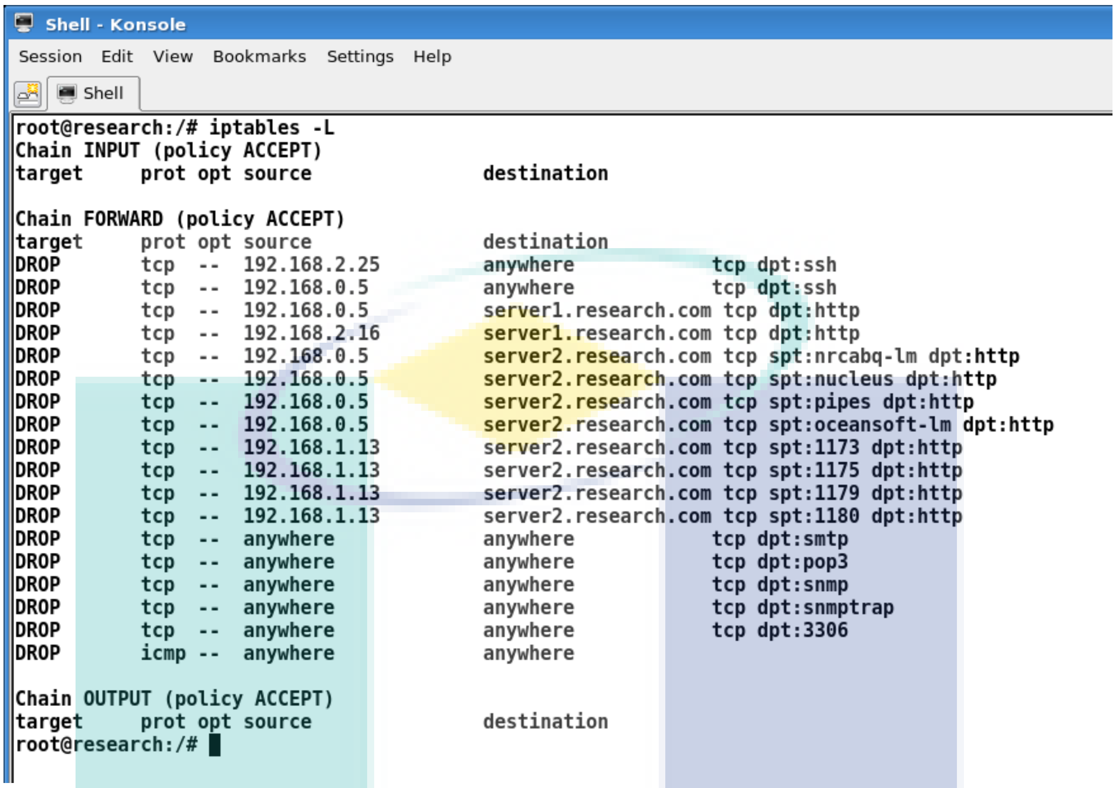
```
root@research:/# iptables -L
Chain INPUT (policy ACCEPT)
target     prot opt source               destination

Chain FORWARD (policy ACCEPT)
target     prot opt source               destination

Chain OUTPUT (policy ACCEPT)
target     prot opt source               destination
root@research:/#
```

Figure 4.26 Default *iptables* firewall rules before enter rules



```
root@research:~# iptables -A FORWARD -p icmp -j DROP
root@research:~# iptables -A FORWARD -p tcp -s 192.168.2.25 --dport 22 -j DROP
root@research:~# iptables -A FORWARD -p tcp -s 192.168.0.5 --dport 22 -j DROP
root@research:~# iptables -A FORWARD -p tcp -s 192.168.0.5 -d 10.10.1.2 --dport 80 -j DROP
root@research:~# iptables -A FORWARD -p tcp -s 192.168.2.16 -d 10.10.1.2 --dport 80 -j DROP
root@research:~# iptables -A FORWARD -p tcp -s 192.168.0.5 --sport 1458 -d 10.10.1.3 --dport 80 -j DROP
root@research:~# iptables -A FORWARD -p tcp -s 192.168.0.5 --sport 1463 -d 10.10.1.3 --dport 80 -j DROP
root@research:~# iptables -A FORWARD -p tcp -s 192.168.0.5 --sport 1465 -d 10.10.1.3 --dport 80 -j DROP
root@research:~# iptables -A FORWARD -p tcp -s 192.168.0.5 --sport 1466 -d 10.10.1.3 --dport 80 -j DROP
root@research:~# iptables -A FORWARD -p tcp -s 192.168.1.13 --sport 1173 -d 10.10.1.3 --dport 80 -j DROP
root@research:~# iptables -A FORWARD -p tcp -s 192.168.1.13 --sport 1175 -d 10.10.1.3 --dport 80 -j DROP
root@research:~# iptables -A FORWARD -p tcp -s 192.168.1.13 --sport 1179 -d 10.10.1.3 --dport 80 -j DROP
root@research:~# iptables -A FORWARD -p tcp -s 192.168.1.13 --sport 1180 -d 10.10.1.3 --dport 80 -j DROP
root@research:~# iptables -A FORWARD -p tcp --dport 25 -j DROP
root@research:~# iptables -A FORWARD -p tcp --dport 110 -j DROP
root@research:~# iptables -A FORWARD -p tcp --dport 161 -j DROP
root@research:~# iptables -A FORWARD -p tcp --dport 162 -j DROP
root@research:~# iptables -A FORWARD -p tcp --dport 3306 -j DROP
root@research:~#
```

Figure 4.27 Command line to enter rules into *iptables* firewall rules



```
root@research:/# iptables -L
Chain INPUT (policy ACCEPT)
target     prot opt source               destination

Chain FORWARD (policy ACCEPT)
target     prot opt source               destination
DROP       tcp  --  192.168.2.25         anywhere            tcp dpt:ssh
DROP       tcp  --  192.168.0.5          anywhere            tcp dpt:ssh
DROP       tcp  --  192.168.0.5          server1.research.com tcp dpt:http
DROP       tcp  --  192.168.2.16         server1.research.com tcp dpt:http
DROP       tcp  --  192.168.0.5          server2.research.com tcp spt:nrcabq-lm dpt:http
DROP       tcp  --  192.168.0.5          server2.research.com tcp spt:nucleus dpt:http
DROP       tcp  --  192.168.0.5          server2.research.com tcp spt:pipes dpt:http
DROP       tcp  --  192.168.0.5          server2.research.com tcp spt:oceansoft-lm dpt:http
DROP       tcp  --  192.168.1.13         server2.research.com tcp spt:1173 dpt:http
DROP       tcp  --  192.168.1.13         server2.research.com tcp spt:1175 dpt:http
DROP       tcp  --  192.168.1.13         server2.research.com tcp spt:1179 dpt:http
DROP       tcp  --  192.168.1.13         server2.research.com tcp spt:1180 dpt:http
DROP       tcp  --  anywhere             anywhere            tcp dpt:smtp
DROP       tcp  --  anywhere             anywhere            tcp dpt:pop3
DROP       tcp  --  anywhere             anywhere            tcp dpt:snmp
DROP       tcp  --  anywhere             anywhere            tcp dpt:snmptrap
DROP       tcp  --  anywhere             anywhere            tcp dpt:3306
DROP       icmp --  anywhere             anywhere

Chain OUTPUT (policy ACCEPT)
target     prot opt source               destination
root@research:/# █
```

Figure 4.28 *Iptables* firewall rules after enter rules

4.7 DECISION TREE TO CREATE RULES MINIMIZE FIREWALL OF INTRUSION

For security all of intrusion activities is show in Tables 4.7 must be drop is shown in Figure 4.29.

```
Ra1    :  -A FORWARD -p icmp –s 192.168.1.25 –d 10.10.1.2 –j DROP
Ra2    :  -A FORWARD -p tcp -s 192.168.2.25 –sport 1142 -d 10.10.1.2 --dport 161 -j DROP
Ra3    :  -A FORWARD -p tcp -s 192.168.2.25 –sport 1143 -d 10.10.1.2 --dport 162 -j DROP
Ra4    :  -A FORWARD -p tcp -s 192.168.2.25 –sport 1179 -d 10.10.1.2 --dport 110 -j DROP
Ra5    :  -A FORWARD -p tcp -s 192.168.2.25 –sport 1175 -d 10.10.1.2 --dport 25 -j DROP
Ra6    :  -A FORWARD -p tcp -s 192.168.2.25 –sport 1130 -d 10.10.1.3 --dport 22 -j DROP
Ra7    :  -A FORWARD -p tcp -s 192.168.2.25 –sport 1131 -d 10.10.1.3 --dport 22 -j DROP
Ra8    :  -A FORWARD -p tcp -s 192.168.2.25 –sport 1345 -d 10.10.1.5 --dport 22 -j DROP
Ra9    :  -A FORWARD -p tcp -s 192.168.2.25 –sport 1347 -d 10.10.1.5 --dport 22 -j DROP
Ra10   :  -A FORWARD -p tcp -s 192.168.2.25 –sport 1348 -d 10.10.1.5 --dport 22 -j DROP
Ra11   :  -A FORWARD -p tcp -s 192.168.2.25 –sport 1351 -d 10.10.1.5 --dport 22 -j DROP
Ra12   :  -A FORWARD -p tcp -s 192.168.2.25 –sport 1352 -d 10.10.1.5 --dport 22 -j DROP
Ra13   :  -A FORWARD -p tcp -s 192.168.2.25 –sport 1356 -d 10.10.1.5 --dport 22 -j DROP
Ra14   :  -A FORWARD -p tcp -s 192.168.2.25 –sport 1354 -d 10.10.1.5 --dport 22 -j DROP
Ra15   :  -A FORWARD -p icmp -s 192.168.0.5 -d 10.10.1.3 -j DROP
Ra16   :  -A FORWARD -p tcp -s 192.168.0.5 –sport 1392 -d 10.10.1.2 --dport 80 -j DROP
Ra17   :  -A FORWARD -p tcp -s 192.168.0.5 –sport 1394 -d 10.10.1.2 --dport 80 -j DROP
Ra18   :  -A FORWARD -p tcp -s 192.168.0.5 –sport 1396 -d 10.10.1.2 --dport 80 -j DROP
Ra19   :  -A FORWARD -p tcp -s 192.168.0.5 –sport 1400 -d 10.10.1.2 --dport 80 -j DROP
Ra20   :  -A FORWARD -p tcp -s 192.168.0.5 –sport 1401 -d 10.10.1.2 --dport 22 -j DROP
Ra21   :  -A FORWARD -p tcp -s 192.168.0.5 –sport 1405 -d 10.10.1.2 --dport 22 -j DROP
Ra22   :  -A FORWARD -p icmp -s 192.168.0.5 -d 10.10.1.3 -j DROP
Ra23   :  -A FORWARD -p tcp -s 192.168.0.5 –sport 1458 -d 10.10.1.3 --dport 80 -j DROP
Ra24   :  -A FORWARD -p tcp -s 192.168.0.5 –sport 1465 -d 10.10.1.3 --dport 80 -j DROP
Ra25   :  -A FORWARD -p tcp -s 192.168.0.5 –sport 1463 -d 10.10.1.3 --dport 80 -j DROP
Ra26   :  -A FORWARD -p tcp -s 192.168.0.5 –sport 1466 -d 10.10.1.3 --dport 80 -j DROP
Ra27   :  -A FORWARD -p tcp -s 192.168.0.5 –sport 1394 -d 10.10.1.5 --dport 22 -j DROP
Ra28   :  -A FORWARD -p tcp -s 192.168.0.5 –sport 1398 -d 10.10.1.5 --dport 22 -j DROP
Ra29   :  -A FORWARD -p tcp -s 192.168.0.5 –sport 1402 -d 10.10.1.5 --dport 22 -j DROP
Ra30   :  -A FORWARD -p tcp -s 192.168.0.5 –sport 1409 -d 10.10.1.5 --dport 22 -j DROP
Ra31   :  -A FORWARD -p tcp -s 192.168.0.5 –sport 1411 -d 10.10.1.5 --dport 22 -j DROP
Ra32   :  -A FORWARD -p tcp -s 192.168.0.5 –sport 1413 -d 10.10.1.5 --dport 22 -j DROP
Ra33   :  -A FORWARD -p tcp -s 192.168.1.13 –sport 1173 -d 10.10.1.3 --dport 80 -j DROP
Ra34   :  -A FORWARD -p tcp -s 192.168.1.13 –sport 1175 -d 10.10.1.3 --dport 80 -j DROP
Ra35   :  -A FORWARD -p tcp -s 192.168.1.13 –sport 1179 -d 10.10.1.3 --dport 80 -j DROP
Ra36   :  -A FORWARD -p tcp -s 192.168.1.13 –sport 1180 -d 10.10.1.3 --dport 80 -j DROP
Ra37   :  -A FORWARD -p tcp -s 192.168.1.13 –sport 1158 -d 10.10.1.2 --dport 25 -j DROP
Ra38   :  -A FORWARD -p icmp -s 192.168.2.16 -d 10.10.1.2 -j DROP
Ra39   :  -A FORWARD -p tcp -s 192.168.2.16 –sport 34592 -d 10.10.1.2 --dport 162 -j DROP
Ra40   :  -A FORWARD -p tcp -s 192.168.2.16 –sport 34595 -d 10.10.1.2 --dport 161 -j DROP
Ra41   :  -A FORWARD -p tcp -s 192.168.2.16 –sport 53814 -d 10.10.1.2 --dport 3306 -j DROP
Ra42   : -A FORWARD -p tcp -s 192.168.2.16 –sport 53815 -d 10.10.1.2 --dport 3306 -j DROP
```

Figure 4.29 All of intrusion activities implemented into firewall rules

Before to develop rules filtering by using packet filter, anything have to be considered beforehand how far demarcation which will be applied. Because more and more demarcation applied hence increased the search time and space requirements of the packet filtering process and consequences to make downhill performance progressively (Al-Shaer E.S. and Hamed H.H., 2006; Suehring S. and Ziegler R.L., 2006 and Predrag Pale T.K., 2007). This matter because every incoming network packet and go out the network checked beforehand by rules alternately until matching rule found in firewall.

To rewrite some of all network traffics (see in Table 4.7) the number row 6, 7, 8, 9, 10, 11, 12, 13 and 14 is shown in Tables 4.18.

Tables 4.18 Some rules of all intrusion activities

No.	Source		Destination		Protocol	Intrusion
	IP	Port	IP	Port		
..	….	…	…	…	…	…
6	192.168.2.25	1130	10.10.1.3	22	TCP	Yes
7	192.168.2.25	1131	10.10.1.3	22	TCP	Yes
8	192.168.2.25	1345	10.10.1.5	22	TCP	Yes
9	192.168.2.25	1347	10.10.1.5	22	TCP	Yes
10	192.168.2.25	1348	10.10.1.5	22	TCP	Yes
11	192.168.2.25	1351	10.10.1.5	22	TCP	Yes
12	192.168.2.25	1352	10.10.1.5	22	TCP	Yes
13	192.168.2.25	1356	10.10.1.5	22	TCP	Yes
14	192.168.2.25	1354	10.10.1.5	22	TCP	Yes
…	…	…	…	…	…	…

All of intrusion characteristic is shown in Tables 4.18 implemented into firewall rules is shown in Figure 4.30.

```
Ra6   :   -A FORWARD -p tcp -s 192.168.2.25 –sport 1130 -d 10.10.1.3 --dport 22 -j DROP
Ra7   :   -A FORWARD -p tcp -s 192.168.2.25 –sport 1131 -d 10.10.1.3 --dport 22 -j DROP
Ra8   :   -A FORWARD -p tcp -s 192.168.2.25 –sport 1345 -d 10.10.1.5 --dport 22 -j DROP
Ra9   :   -A FORWARD -p tcp -s 192.168.2.25 –sport 1347 -d 10.10.1.5 --dport 22 -j DROP
Ra10  :   -A FORWARD -p tcp -s 192.168.2.25 –sport 1348 -d 10.10.1.5 --dport 22 -j DROP
Ra11  :   -A FORWARD -p tcp -s 192.168.2.25 –sport 1351 -d 10.10.1.5 --dport 22 -j DROP
Ra12  :   -A FORWARD -p tcp -s 192.168.2.25 –sport 1352 -d 10.10.1.5 --dport 22 -j DROP
Ra13  :   -A FORWARD -p tcp -s 192.168.2.25 –sport 1356 -d 10.10.1.5 --dport 22 -j DROP
Ra14  :   -A FORWARD -p tcp -s 192.168.2.25 –sport 1354 -d 10.10.1.5 --dport 22 -j DROP
```

Figure 4.30 Some rules from all of intrusion activities

By using the decision tree all of rule above all represented by one rule is shown in Figure 4.31.

```
R2    :  -A FORWARD -p tcp -s 192.168.2.25 --dport 22 -j DROP
```

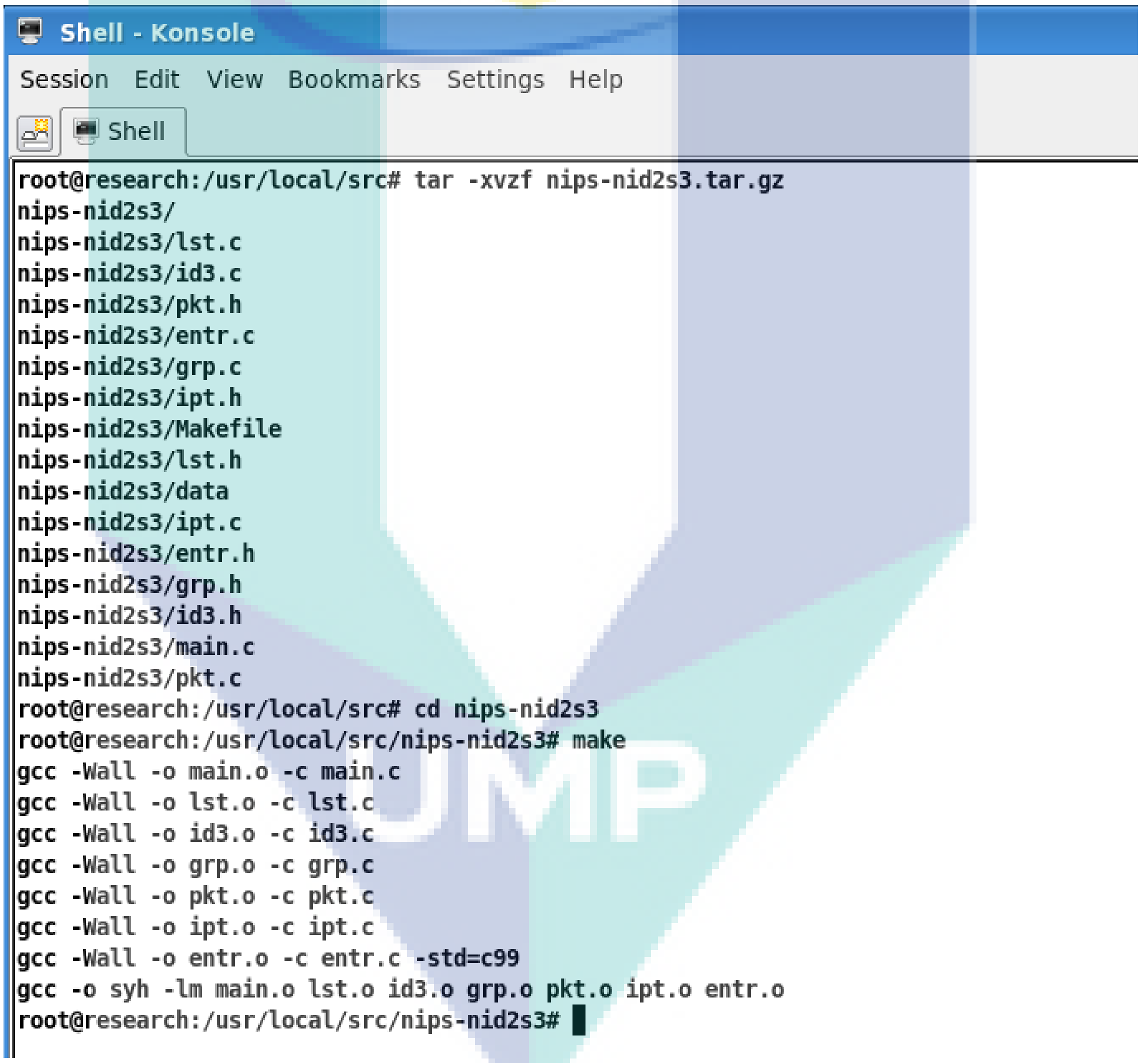
Figure 4.31. *R2* represent *Ra6*, *Ra7*, *Ra8*, *Ra9*, *Ra10*, *Ra11*, *Ra12*, *Ra13*, *Ra14*

If the observed of all network traffic that has Protocol = TCP, source IP = 192.168.2.25 and Destination Port = 22 and any value of Destination IP is intrusion. So, do not need Destination IP for rules, because anything values of Destination IP that has Protocol = TCP, source IP = 192.168.2.25 and Destination Port = 22 is intrusion. Based on all of network traffics *R2* represent and replace *Ra6*, *Ra7*, *Ra8*, *Ra9*, *Ra10*, *Ra11*, *Ra12*, *Ra13*, *Ra14*. Same case for other rules.

By using decision tree and all data training is shown Table 4.7, 42 rules of intrusion activities network traffics to represent 17 rules will implemented into firewall rules. Compare between Figure 4.25 and Figure 4.29, by using decision tree, one rule to represent two or more rules. This is become simple rules to be implemented firewall rules.

4.8 EXPERIMENTAL AND RESULT

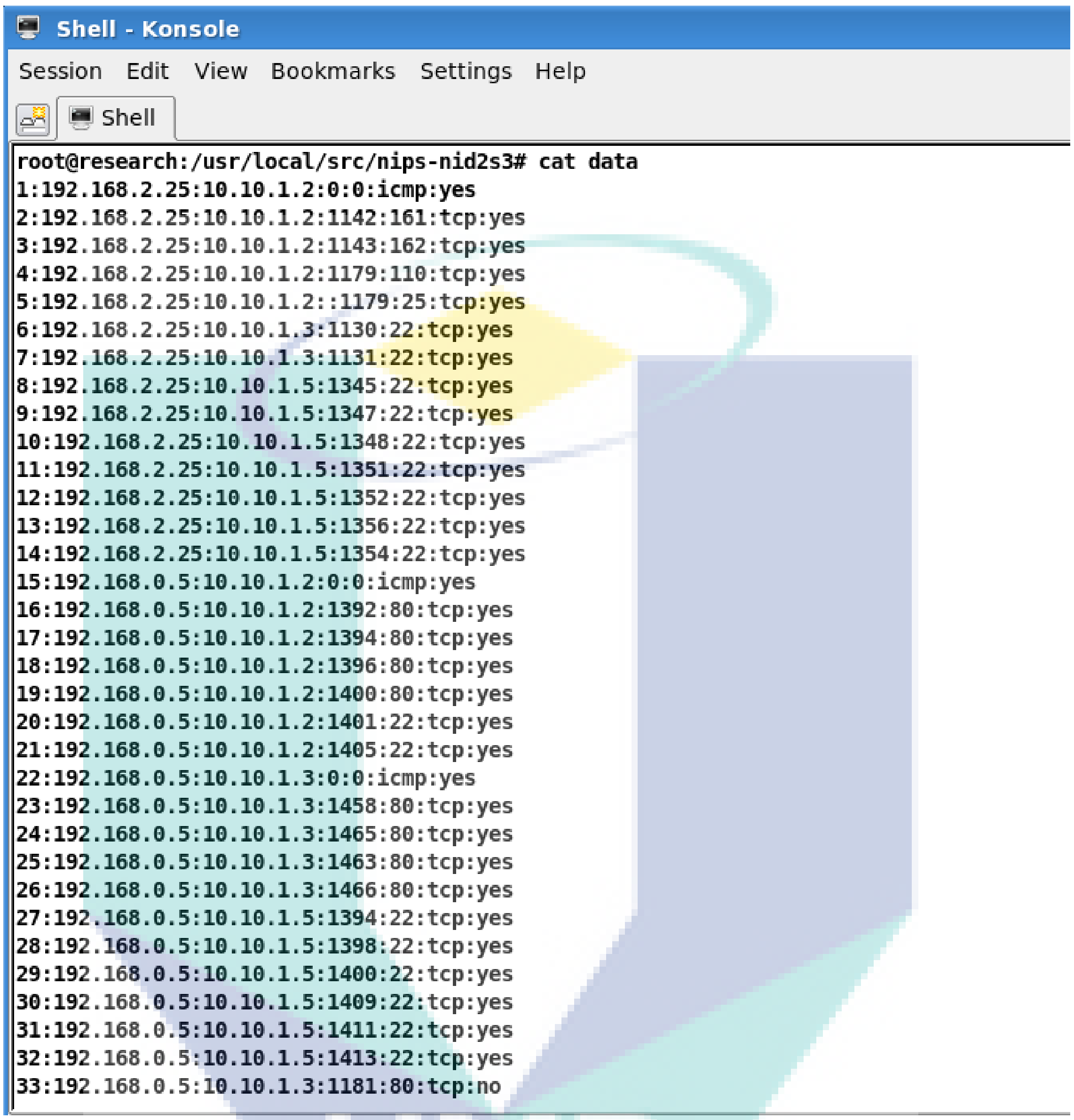
For the calculation of ID3 algorithm and then implemented directly in the *iptables* firewall rules automatically be made software. The name is software *nips-nid2s3*. This software is running in Linux Operating System. This research, computers as routers and firewalls using Linux Slackware 12.1. Figure 4.32 shows the extract and compile *nips-nid2s3* software.



```
root@research:/usr/local/src# tar -xvzf nips-nid2s3.tar.gz
nips-nid2s3/
nips-nid2s3/lst.c
nips-nid2s3/id3.c
nips-nid2s3/pkt.h
nips-nid2s3/entr.c
nips-nid2s3/grp.c
nips-nid2s3/ipt.h
nips-nid2s3/Makefile
nips-nid2s3/lst.h
nips-nid2s3/data
nips-nid2s3/ipt.c
nips-nid2s3/entr.h
nips-nid2s3/grp.h
nips-nid2s3/id3.h
nips-nid2s3/main.c
nips-nid2s3/pkt.c
root@research:/usr/local/src# cd nips-nid2s3
root@research:/usr/local/src/nips-nid2s3# make
gcc -Wall -o main.o -c main.c
gcc -Wall -o lst.o -c lst.c
gcc -Wall -o id3.o -c id3.c
gcc -Wall -o grp.o -c grp.c
gcc -Wall -o pkt.o -c pkt.c
gcc -Wall -o ipt.o -c ipt.c
gcc -Wall -o entr.o -c entr.c -std=c99
gcc -o syh -lm main.o lst.o id3.o grp.o pkt.o ipt.o entr.o
root@research:/usr/local/src/nips-nid2s3# 
```

Figure 4.32 Extract and compile software *nips-nid2s3*

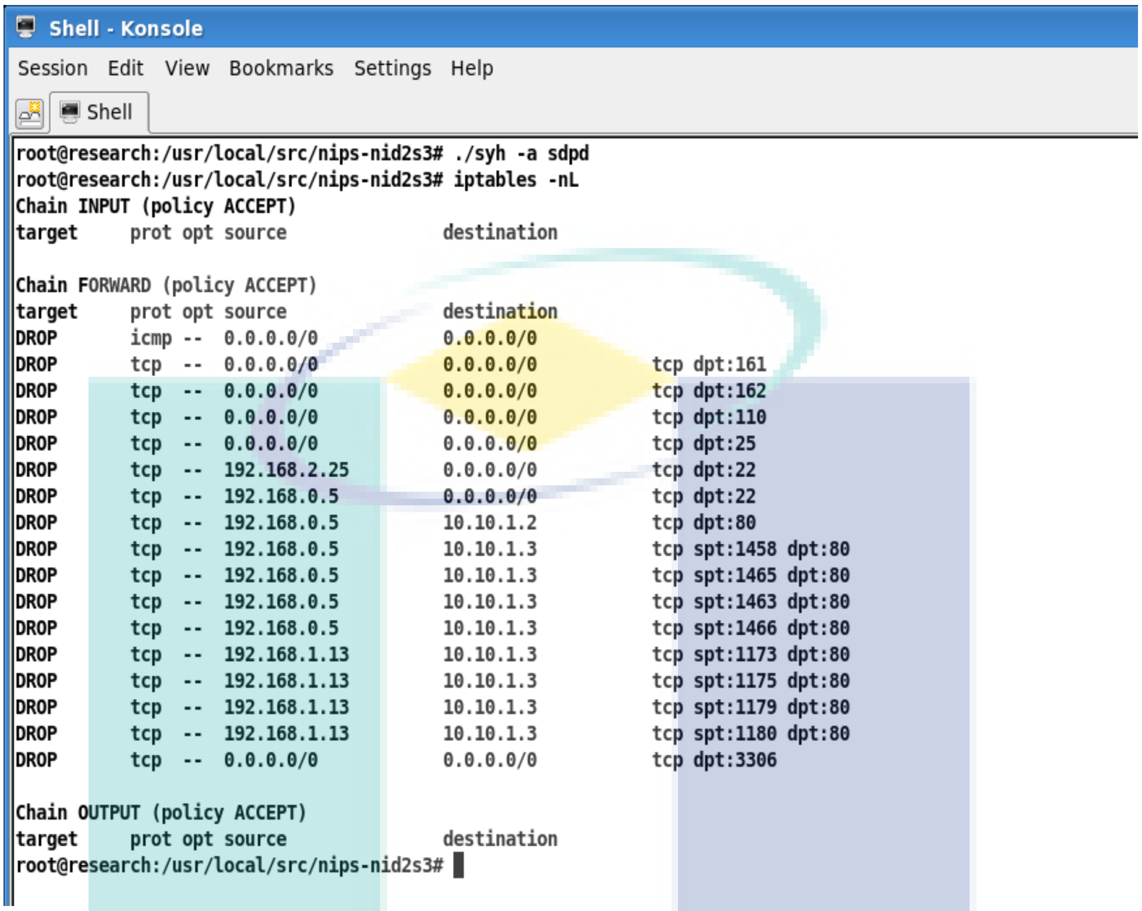
All of data training in Table 4.7 contained in the file 'data' is shown in Figure 4.33



```
root@research:/usr/local/src/nips-nid2s3# cat data
1:192.168.2.25:10.10.1.2:0:0:icmp:yes
2:192.168.2.25:10.10.1.2:1142:161:tcp:yes
3:192.168.2.25:10.10.1.2:1143:162:tcp:yes
4:192.168.2.25:10.10.1.2:1179:110:tcp:yes
5:192.168.2.25:10.10.1.2::1179:25:tcp:yes
6:192.168.2.25:10.10.1.3:1130:22:tcp:yes
7:192.168.2.25:10.10.1.3:1131:22:tcp:yes
8:192.168.2.25:10.10.1.5:1345:22:tcp:yes
9:192.168.2.25:10.10.1.5:1347:22:tcp:yes
10:192.168.2.25:10.10.1.5:1348:22:tcp:yes
11:192.168.2.25:10.10.1.5:1351:22:tcp:yes
12:192.168.2.25:10.10.1.5:1352:22:tcp:yes
13:192.168.2.25:10.10.1.5:1356:22:tcp:yes
14:192.168.2.25:10.10.1.5:1354:22:tcp:yes
15:192.168.0.5:10.10.1.2:0:0:icmp:yes
16:192.168.0.5:10.10.1.2:1392:80:tcp:yes
17:192.168.0.5:10.10.1.2:1394:80:tcp:yes
18:192.168.0.5:10.10.1.2:1396:80:tcp:yes
19:192.168.0.5:10.10.1.2:1400:80:tcp:yes
20:192.168.0.5:10.10.1.2:1401:22:tcp:yes
21:192.168.0.5:10.10.1.2:1405:22:tcp:yes
22:192.168.0.5:10.10.1.3:0:0:icmp:yes
23:192.168.0.5:10.10.1.3:1458:80:tcp:yes
24:192.168.0.5:10.10.1.3:1465:80:tcp:yes
25:192.168.0.5:10.10.1.3:1463:80:tcp:yes
26:192.168.0.5:10.10.1.3:1466:80:tcp:yes
27:192.168.0.5:10.10.1.5:1394:22:tcp:yes
28:192.168.0.5:10.10.1.5:1398:22:tcp:yes
29:192.168.0.5:10.10.1.5:1400:22:tcp:yes
30:192.168.0.5:10.10.1.5:1409:22:tcp:yes
31:192.168.0.5:10.10.1.5:1411:22:tcp:yes
32:192.168.0.5:10.10.1.5:1413:22:tcp:yes
33:192.168.0.5:10.10.1.3:1181:80:tcp:no
```

Figure 4.33 All of data training in ‘data’ file

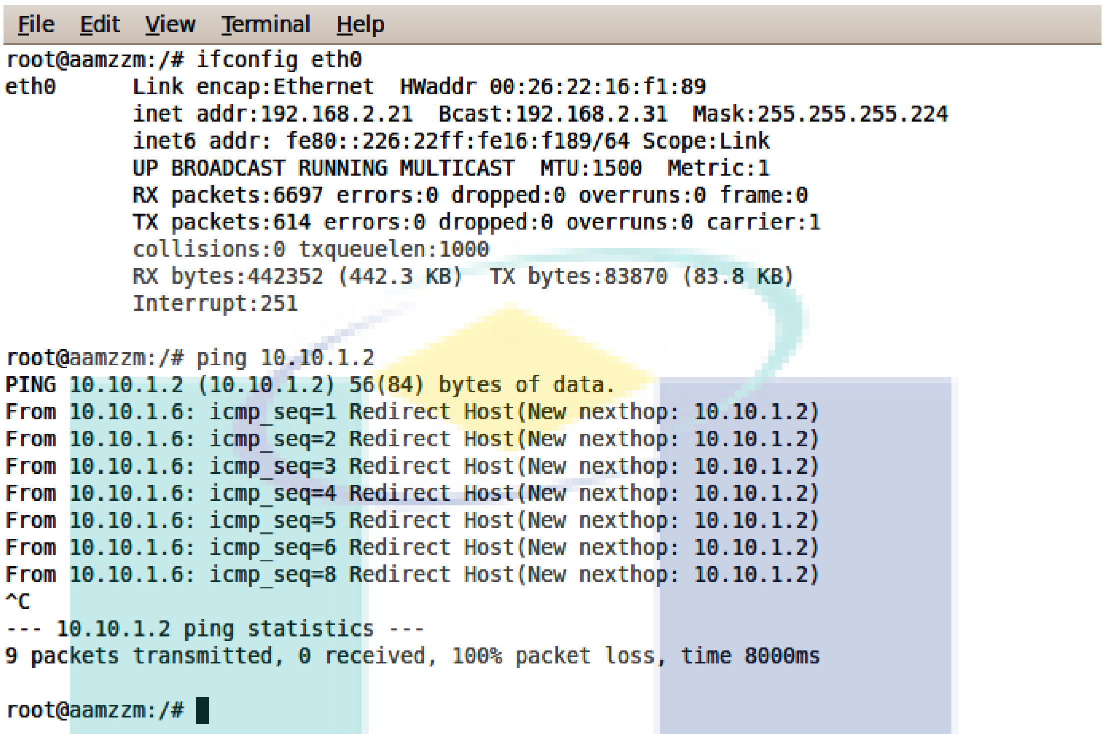
Execute program using command `./syh -a sdpd` and then to see *iptables* firewall rules is shown in Figure 4.34.



```
root@research:/usr/local/src/nips-nid2s3# ./syh -a sdpd
root@research:/usr/local/src/nips-nid2s3# iptables -nL
Chain INPUT (policy ACCEPT)
target     prot opt source               destination

Chain FORWARD (policy ACCEPT)
target     prot opt source               destination
DROP       icmp --  0.0.0.0/0            0.0.0.0/0
DROP       tcp  --  0.0.0.0/0            0.0.0.0/0           tcp dpt:161
DROP       tcp  --  0.0.0.0/0            0.0.0.0/0           tcp dpt:162
DROP       tcp  --  0.0.0.0/0            0.0.0.0/0           tcp dpt:110
DROP       tcp  --  0.0.0.0/0            0.0.0.0/0           tcp dpt:25
DROP       tcp  --  192.168.2.25         0.0.0.0/0           tcp dpt:22
DROP       tcp  --  192.168.0.5          0.0.0.0/0           tcp dpt:22
DROP       tcp  --  192.168.0.5          10.10.1.2           tcp dpt:80
DROP       tcp  --  192.168.0.5          10.10.1.3           tcp spt:1458 dpt:80
DROP       tcp  --  192.168.0.5          10.10.1.3           tcp spt:1465 dpt:80
DROP       tcp  --  192.168.0.5          10.10.1.3           tcp spt:1463 dpt:80
DROP       tcp  --  192.168.0.5          10.10.1.3           tcp spt:1466 dpt:80
DROP       tcp  --  192.168.1.13         10.10.1.3           tcp spt:1173 dpt:80
DROP       tcp  --  192.168.1.13         10.10.1.3           tcp spt:1175 dpt:80
DROP       tcp  --  192.168.1.13         10.10.1.3           tcp spt:1179 dpt:80
DROP       tcp  --  192.168.1.13         10.10.1.3           tcp spt:1180 dpt:80
DROP       tcp  --  0.0.0.0/0            0.0.0.0/0           tcp dpt:3306

Chain OUTPUT (policy ACCEPT)
target     prot opt source               destination
root@research:/usr/local/src/nips-nid2s3# 
```

Figure 4.34 Execute and then to see into firewall rules

In Figure 4.34 shows how to is to create 17 rules into firewall. The rule in line 1, that is mean is all of network packets use protocol ICMP is drop.



```
root@aamzzm:/# ifconfig eth0
eth0      Link encap:Ethernet  HWaddr 00:26:22:16:f1:89
          inet addr:192.168.2.21  Bcast:192.168.2.31  Mask:255.255.255.224
          inet6 addr: fe80::226:22ff:fe16:f189/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:6697 errors:0 dropped:0 overruns:0 frame:0
          TX packets:614 errors:0 dropped:0 overruns:0 carrier:1
          collisions:0 txqueuelen:1000
          RX bytes:442352 (442.3 KB)  TX bytes:83870 (83.8 KB)
          Interrupt:251

root@aamzzm:/# ping 10.10.1.2
PING 10.10.1.2 (10.10.1.2) 56(84) bytes of data.
From 10.10.1.6: icmp_seq=1 Redirect Host(New nexthop: 10.10.1.2)
From 10.10.1.6: icmp_seq=2 Redirect Host(New nexthop: 10.10.1.2)
From 10.10.1.6: icmp_seq=3 Redirect Host(New nexthop: 10.10.1.2)
From 10.10.1.6: icmp_seq=4 Redirect Host(New nexthop: 10.10.1.2)
From 10.10.1.6: icmp_seq=5 Redirect Host(New nexthop: 10.10.1.2)
From 10.10.1.6: icmp_seq=6 Redirect Host(New nexthop: 10.10.1.2)
From 10.10.1.6: icmp_seq=8 Redirect Host(New nexthop: 10.10.1.2)
^C
--- 10.10.1.2 ping statistics ---
9 packets transmitted, 0 received, 100% packet loss, time 8000ms

root@aamzzm:/# 
```

Figure 4.35 Ping using protocol ICMP from 192.168.2.21 to 10.10.1.2 is not reply

Researcher tries computer client connect to server using protocol ICMP as shown in Figure 4.35. This packet network to drop and not allow forwarded by firewall. The network traffics have characteristics same match into firewall rules at line 1, that is mean network packet has Protocol = ICMP is drop. This network packet is intrusion. Firewall cannot allow forwarded a network packet has Protocol=ICMP.

For another, researcher tries to request to server, which request from client has characteristics of intrusion.

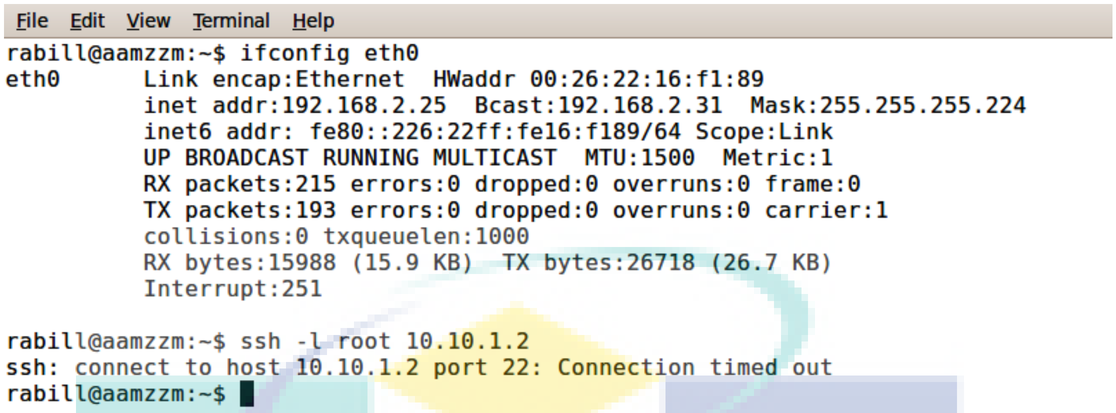
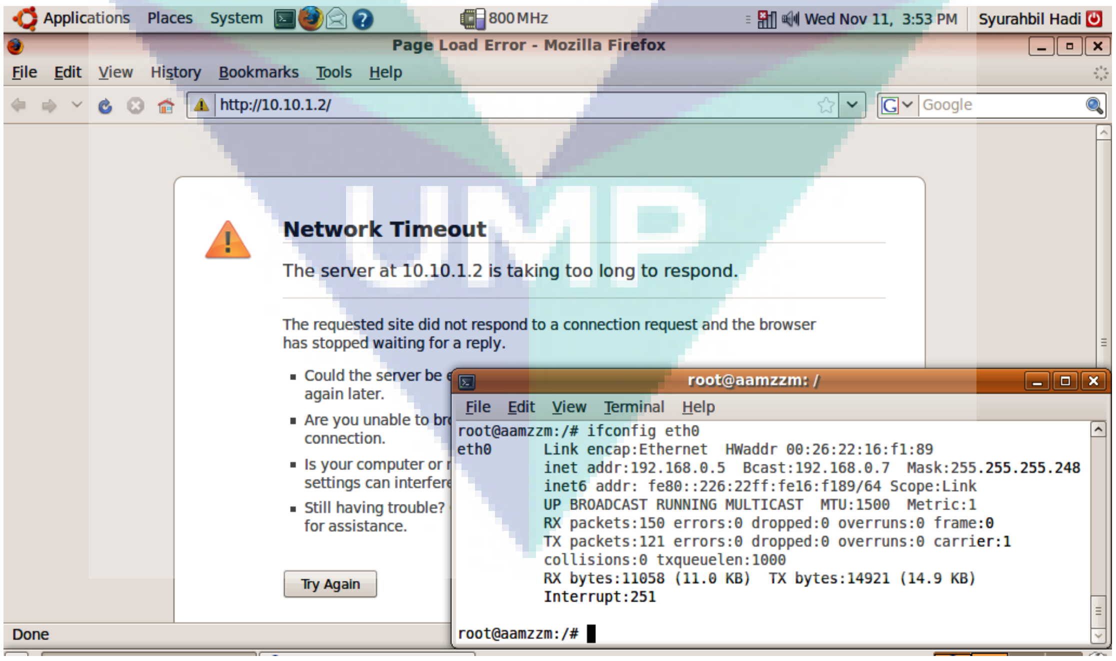

File Edit View Terminal Help
```
rabill@aamzzm:~$ ifconfig eth0
eth0      Link encap:Ethernet  HWaddr 00:26:22:16:f1:89
          inet addr:192.168.2.25  Bcast:192.168.2.31  Mask:255.255.255.224
          inet6 addr: fe80::226:22ff:fe16:f189/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:215 errors:0 dropped:0 overruns:0 frame:0
          TX packets:193 errors:0 dropped:0 overruns:0 carrier:1
          collisions:0 txqueuelen:1000
          RX bytes:15988 (15.9 KB)  TX bytes:26718 (26.7 KB)
          Interrupt:251

rabill@aamzzm:~$ ssh -l root 10.10.1.2
ssh: connect to host 10.10.1.2 port 22: Connection timed out
rabill@aamzzm:~$ 
```

Figure 4.36 Request SSH from 192.168.2.25 to 10.10.1.2 is connection timed out

In Figure 4.36 is someone has IP address 192.168.2.25 connect to 10.10.1.2 by SSH service (port 22) is connection timed out. This packet network to drop and not allow forwarded by firewall. The network traffics have characteristics same match into firewall rules at line 6, that is mean network packet has Protocol = TCP and source IP = 192.168.2.25 and Destination Port = 20 any value of Destination IP action is drop. This network packet is intrusion. Firewall cannot allow forwarded.


Applications Places System
800 MHz
Wed Nov 11, 3:53 PM
Syurahbil Hadi
Page Load Error - Mozilla Firefox
File Edit View History Bookmarks Tools Help
http://10.10.1.2/
Google
Try Again
Done
root@aamzzm: /
File Edit View Terminal Help

Network Timeout

The server at 10.10.1.2 is taking too long to respond.

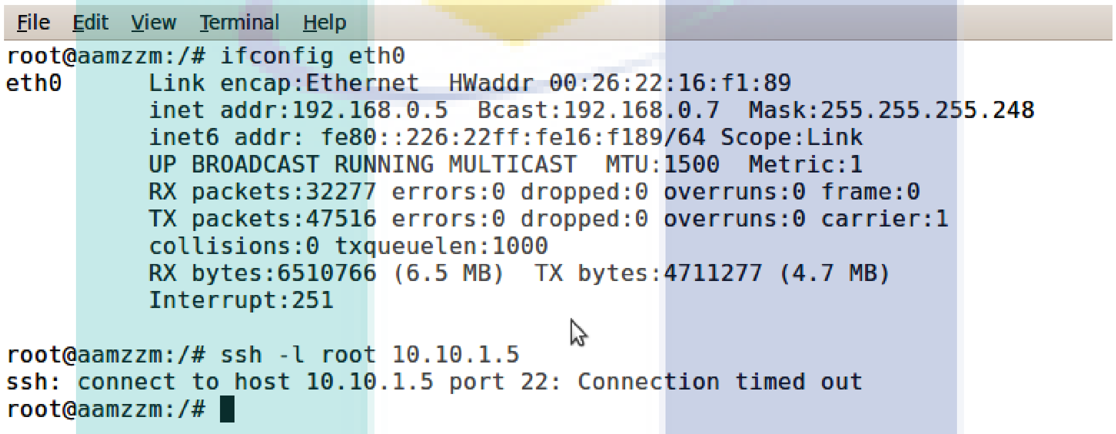
The requested site did not respond to a connection request and the browser has stopped waiting for a reply.

- Could the server be [illegible] again later.
- Are you unable to br[illegible] connection.
- Is your computer or [illegible] settings can interfere
- Still having trouble? [illegible] for assistance.

```
root@aamzzm:/# ifconfig eth0
eth0      Link encap:Ethernet  HWaddr 00:26:22:16:f1:89
          inet addr:192.168.0.5  Bcast:192.168.0.7  Mask:255.255.255.248
          inet6 addr: fe80::226:22ff:fe16:f189/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:150 errors:0 dropped:0 overruns:0 frame:0
          TX packets:121 errors:0 dropped:0 overruns:0 carrier:1
          collisions:0 txqueuelen:1000
          RX bytes:11058 (11.0 KB)  TX bytes:14921 (14.9 KB)
          Interrupt:251

root@aamzzm:/# 
```

Figure 4.37 Request URL from 192.168.0.5 to 10.10.1.2 is taking too long to respond

In Figure 4.37 is someone has IP address 192.168.0.5 connect request Web browser (port 80) to 10.10.1.2 port 80 s taking too long to respond. This network to drop and not allow forwarded by firewall. The network traffics have characteristics same match into firewall rules at line 8, that is mean network packet has Protocol = TCP and source IP = 192.168.0.5 and Destination IP = 10.10.1.2 and Destination Port = 80 action is drop. This network packet is intrusion. Firewall cannot allow forwarded.



```
root@aamzzm:/# ifconfig eth0
eth0      Link encap:Ethernet  HWaddr 00:26:22:16:f1:89
          inet addr:192.168.0.5  Bcast:192.168.0.7  Mask:255.255.255.248
          inet6 addr: fe80::226:22ff:fe16:f189/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:32277 errors:0 dropped:0 overruns:0 frame:0
          TX packets:47516 errors:0 dropped:0 overruns:0 carrier:1
          collisions:0 txqueuelen:1000
          RX bytes:6510766 (6.5 MB)  TX bytes:4711277 (4.7 MB)
          Interrupt:251

root@aamzzm:/# ssh -l root 10.10.1.5
ssh: connect to host 10.10.1.5 port 22: Connection timed out
root@aamzzm:/#
```

Figure 4.38 Request SSH from 192.168.0. 5 to 10.10.1.5 is connection timed out

In Figure 4.38 is someone has IP address 192.168.0.5 connect to 10.10.1.5 by SSH service (port 22) is connection timed out. This packet network to drop and not allow forwarded by firewall. The network traffics have characteristics same match into firewall rules at line 7, that is mean network packet has Protocol = TCP and source IP = 192.168.0.5 and Destination Port = 22 and any value of Destination IP action is drop. This network packet is intrusion. Firewall cannot allow forwarded.

4.9 CONCLUSION

In this chapter, the implementation has generate rules of intrusion as NIDS and to implemented into firewall as prevention. Three LAN have been develop to support the client request to server. A computer become router and firewall which have been connected in LAN. It is a function to record log files. *Snort* software has been used to determine either the intrusion or normal activities and from the log files. Decision tree has been used to generate rules. Next, these rules implemented into firewall as prevention of intrusion network packet. These the filter rules reflect the current network traffics. Overall, this way can minimize the number of that implemented in firewall.

CHAPTER 5

CONCLUSION AND RECOMENDATIONS

5.1 CONCLUSION

Network security has become a critical issue with the development of business and other transactions through the internet system. Firewall is one important element in network security systems because it can drop the a network packet incoming to LAN. Firewall can not define a network packet is intrusion or normal. An intrusion can be defined as any set of actions that threaten the integrity, confidentiality or availability of a network resource, such as user account, file system, system kernels and so on. Specifies the network packet is intrusion to be implemented on the firewall rules are very difficult. An analyst should reviews large data from network traffics previously. Meanwhile, to update and manage the firewall rules are very difficult and takes a lot of time.

By using the ID3 algorithm decision tree classifier to generate rules where network traffics as data training. A network packet from the network traffics can be seen from the log files. To determine the network packet is intrusion or normal using *snort* application.

Rules generated can determine a new network packet is intrusion or normal. These rules are implemented into firewall automatically where the firewall will drop the network packet that match those rules as intrusion.

This research contributes: first, to create rules that function to determine the network traffic is the intrusion and then implemented rules into the firewall as a prevention automatically. This combination is called NIPS, because it can determine network packet is intrusion automatically and can be prevented by using a firewall.

This method can minimize the number of rules in the firewall, where one rule can replace two or more rules and make a better firewall performance. This is very helpful and easier to update and manage the firewall rules.

This research made software that is named *nips-nids2s3*, this software helps construct decision tree to generate the rules and implemented into firewall *iptables* automatically as prevention.

5.2 RECOMMENDATIONS

Data collection for intrusion do if the network packets do intrusion several times from the same source IP address. If intrusion is conducted just one time, it can be an unintentionally and ignored. Intruder do many times intrusion many times, with goal to find and get as much as information from a machine target. Intruder takes a lot of time and in many ways to get information such as port scans, ping, send packages, etc. It is impossible intruder to do intrusion just once.

In large computer networks, this condition will produces large data set and also generate so many rules. It is recommended reduces some rules become one rule using the port range or multi port and IP range or IP network by masking the same protocol and action.

For future work, the whole way this is done with real time system and performed on large computer networks such as Wide Area Network (WAN) and internet.

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APPENDIX A

NETWORK TRAFFIC LOGS

i) Intrusion Activities Logs using *snort* software in folder `/var/log/snort/alert`

```
[**] [1:1418:13] SNMP request tcp [**]
[Classification: Attempted Information Leak] [Priority: 2]
12/09-22:20:30.747206 0:8:2:E1:27:AA -> 0:0:B4:98:21:B0 type:0x800 len:0x3E
192.168.2.25:1142 -> 10.10.1.2:161 TCP TTL:128 TOS:0x0 ID:7545 IpLen:20 DgmLen:48 DF
******S* Seq: 0x9C20F9B4  Ack: 0x0  Win: 0xFFFF  TcpLen: 28
TCP Options (4) => MSS: 1460 NOP NOP SackOK
[Xref => http://cve.mitre.org/cgi-bin/cvename.cgi?name=2002-0013][Xref =>
http://cve.mitre.org/cgi-bin/cvename.cgi?name=2002-0012][Xref =>
http://www.securityfocus.com/bid/4132][Xref => http://www.securityfocus.com/bid/4089]
[Xref => http://www.securityfocus.com/bid/4088]

[**] [1:1420:13] SNMP trap tcp [**]
[Classification: Attempted Information Leak] [Priority: 2]
12/09-22:20:30.747603 0:8:2:E1:27:AA -> 0:0:B4:98:21:B0 type:0x800 len:0x3E
192.168.2.25:1143 -> 10.10.1.2:162 TCP TTL:128 TOS:0x0 ID:7546 IpLen:20 DgmLen:48 DF
******S* Seq: 0x604278A  Ack: 0x0  Win: 0xFFFF  TcpLen: 28
TCP Options (4) => MSS: 1460 NOP NOP SackOK
[Xref => http://cve.mitre.org/cgi-bin/cvename.cgi?name=2002-0013][Xref =>
http://cve.mitre.org/cgi-bin/cvename.cgi?name=2002-0012][Xref =>
http://www.securityfocus.com/bid/4132][Xref => http://www.securityfocus.com/bid/4089]
[Xref => http://www.securityfocus.com/bid/4088]

[**] [1:472:5] ICMP redirect host [**]
[Classification: Potentially Bad Traffic] [Priority: 2]
12/09-22:20:30.855749 0:0:B4:98:21:B0 -> 0:55:D0:F1:DC:1B type:0x800 len:0x57
192.168.2.30 -> 10.10.1.2 ICMP TTL:64 TOS:0xC0 ID:40045 IpLen:20 DgmLen:73
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.2.25
** ORIGINAL DATAGRAM DUMP:
10.10.1.2:110 -> 192.168.2.25:1179 TCP TTL:64 TOS:0x0 ID:49893 IpLen:20 DgmLen:45 DF
Seq: 0x7E37D69E
(17 more bytes of original packet)
** END OF DUMP
[Xref => http://cve.mitre.org/cgi-bin/cvename.cgi?name=1999-0265][Xref =>
http://www.whitehats.com/info/IDS135]

[**] [1:472:5] ICMP redirect host [**]
[Classification: Potentially Bad Traffic] [Priority: 2]
12/09-22:20:50.836055 0:0:B4:98:21:B0 -> 0:55:D0:F1:DC:1B type:0x800 len:0xAA
192.168.2.30 -> 10.10.1.2 ICMP TTL:64 TOS:0xC0 ID:40048 IpLen:20 DgmLen:156
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.2.25
** ORIGINAL DATAGRAM DUMP:
10.10.1.2:25 -> 192.168.2.25:1175 TCP TTL:64 TOS:0x0 ID:44216 IpLen:20 DgmLen:128 DF
Seq: 0x7EDBB8CC
(100 more bytes of original packet)
** END OF DUMP
[Xref => http://cve.mitre.org/cgi-bin/cvename.cgi?name=1999-0265][Xref =>
http://www.whitehats.com/info/IDS135]

[**] [1:472:5] ICMP redirect host [**]
[Classification: Potentially Bad Traffic] [Priority: 2]
12/10-02:59:45.547181 0:0:B4:98:21:B0 -> 0:55:D0:F1:DC:1B type:0x800 len:0x5A
192.168.2.30 -> 10.10.1.2 ICMP TTL:64 TOS:0xC0 ID:18410 IpLen:20 DgmLen:76
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.0.5
```

```
** ORIGINAL DATAGRAM DUMP:
10.10.1.2:80 -> 192.168.0.5:1392 TCP TTL:64 TOS:0x0 ID:0 IpLen:20 DgmLen:48 DF
Seq: 0xABA54F77
(20 more bytes of original packet)
** END OF DUMP
[Xref => http://cve.mitre.org/cgi-bin/cvename.cgi?name=1999-0265][Xref =>
http://www.whitehats.com/info/IDS135]

[**] [1:472:5] ICMP redirect host [**]
[Classification: Potentially Bad Traffic] [Priority: 2]
12/10-02:59:46.686349 0:0:B4:98:21:B0 -> 0:55:D0:F1:DC:1B type:0x800 len:0x5A
192.168.2.30 -> 10.10.1.2 ICMP TTL:64 TOS:0xC0 ID:18412 IpLen:20 DgmLen:76
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.0.5
** ORIGINAL DATAGRAM DUMP:
10.10.1.2:80 -> 192.168.0.5:1394 TCP TTL:64 TOS:0x0 ID:0 IpLen:20 DgmLen:48 DF
Seq: 0xAC888CBE
(20 more bytes of original packet)
** END OF DUMP
[Xref => http://cve.mitre.org/cgi-bin/cvename.cgi?name=1999-0265][Xref =>
http://www.whitehats.com/info/IDS135]

[**] [1:895:8] WEB-CGI redirect access [**]
[Classification: Attempted Information Leak] [Priority: 2]
12/10-03:00:00.599880 0:8:2:E1:27:AA -> 0:0:B4:98:21:B0 type:0x800 len:0x302
192.168.0.5:1396 -> 10.10.1.2:80 TCP TTL:128 TOS:0x0 ID:11173 IpLen:20 DgmLen:756 DF
***AP*** Seq: 0xD388FFCD  Ack: 0xB99FF92F  Win: 0xFFFF  TcpLen: 20
[Xref => http://cve.mitre.org/cgi-bin/cvename.cgi?name=2000-0382][Xref =>
http://www.securityfocus.com/bid/1179

[**] [1:895:8] WEB-CGI redirect access [**]
[Classification: Attempted Information Leak] [Priority: 2]
12/10-03:00:16.855182 0:8:2:E1:27:AA -> 0:0:B4:98:21:B0 type:0x800 len:0x303
192.168.0.5:1400 -> 10.10.1.2:80 TCP TTL:128 TOS:0x0 ID:11236 IpLen:20 DgmLen:757 DF
***AP*** Seq: 0xC303018D  Ack: 0xC7F84882  Win: 0xFFFF  TcpLen: 20
[Xref => http://cve.mitre.org/cgi-bin/cvename.cgi?name=2000-0382][Xref =>
http://www.securityfocus.com/bid/1179]

[**] [1:472:5] ICMP redirect host [**]
[Classification: Potentially Bad Traffic] [Priority: 2]
12/10-03:00:46.282528 0:0:B4:98:21:B0 -> 0:55:D0:F1:DC:1B type:0x800 len:0x5A
192.168.2.30 -> 10.10.1.2 ICMP TTL:64 TOS:0xC0 ID:18419 IpLen:20 DgmLen:76
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.0.5
** ORIGINAL DATAGRAM DUMP:
10.10.1.2:22 -> 192.168.0.5:1401 TCP TTL:64 TOS:0x0 ID:0 IpLen:20 DgmLen:48 DF
Seq: 0xE4079F59
(20 more bytes of original packet)
** END OF DUMP
[Xref => http://cve.mitre.org/cgi-bin/cvename.cgi?name=1999-0265][Xref =>
http://www.whitehats.com/info/IDS135]

[**] [1:472:5] ICMP redirect host [**]
[Classification: Potentially Bad Traffic] [Priority: 2]
12/10-03:01:56.097112 0:0:B4:98:21:B0 -> 0:55:D0:F1:DC:1B type:0x800 len:0x5A
192.168.2.30 -> 10.10.1.2 ICMP TTL:64 TOS:0xC0 ID:18427 IpLen:20 DgmLen:76
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.0.5
** ORIGINAL DATAGRAM DUMP:
10.10.1.2:22 -> 192.168.0.5:1405 TCP TTL:64 TOS:0x0 ID:0 IpLen:20 DgmLen:48 DF
Seq: 0x24DCE69E
(20 more bytes of original packet)
** END OF DUMP
[Xref => http://cve.mitre.org/cgi-bin/cvename.cgi?name=1999-0265][Xref =>
http://www.whitehats.com/info/IDS135]

[**] [1:472:5] ICMP redirect host [**]
[Classification: Potentially Bad Traffic] [Priority: 2]
12/10-03:24:22.285346 0:0:B4:98:21:B0 -> 0:55:D0:F1:DC:1B type:0x800 len:0x7E
```

```
192.168.2.30 -> 10.10.1.3 ICMP TTL:64 TOS:0xC0 ID:47275 IpLen:20 DgmLen:112
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.0.5
** ORIGINAL DATAGRAM DUMP:
10.10.1.3 -> 192.168.0.5 ICMP TTL:64 TOS:0x0 ID:0 IpLen:20 DgmLen:84 DF
Type: 8  Code: 0  Csum: 26953  Id: 3850  SeqNo: 1
(56 more bytes of original packet)
** END OF DUMP
[Xref => http://cve.mitre.org/cgi-bin/cvename.cgi?name=1999-0265][Xref =>
http://www.whitehats.com/info/IDS135]

[**] [1:472:5] ICMP redirect host [**]
[Classification: Potentially Bad Traffic] [Priority: 2]
12/10-03:25:42.348971 0:0:B4:98:21:B0 -> 0:55:D0:F1:DC:1B type:0x800 len:0x5A
192.168.2.30 -> 10.10.1.3 ICMP TTL:64 TOS:0xC0 ID:47284 IpLen:20 DgmLen:76
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.0.5
** ORIGINAL DATAGRAM DUMP:
10.10.1.3:80 -> 192.168.0.5:1458 TCP TTL:64 TOS:0x0 ID:0 IpLen:20 DgmLen:48 DF
Seq: 0x16D4FD96
(20 more bytes of original packet)
** END OF DUMP
[Xref => http://cve.mitre.org/cgi-bin/cvename.cgi?name=1999-0265][Xref =>
http://www.whitehats.com/info/IDS135]

[**] [1:472:5] ICMP redirect host [**]
[Classification: Potentially Bad Traffic] [Priority: 2]
12/10-03:25:44.042042 0:0:B4:98:21:B0 -> 0:55:D0:F1:DC:1B type:0x800 len:0x24E
192.168.2.30 -> 10.10.1.3 ICMP TTL:64 TOS:0xC0 ID:47287 IpLen:20 DgmLen:576
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.0.5
** ORIGINAL DATAGRAM DUMP:
10.10.1.3:80 -> 192.168.0.5:1465 TCP TTL:64 TOS:0x0 ID:47643 IpLen:20 DgmLen:1500 DF
Seq: 0x17899CAE
(520 more bytes of original packet)
** END OF DUMP
[Xref => http://cve.mitre.org/cgi-bin/cvename.cgi?name=1999-0265][Xref =>
http://www.whitehats.com/info/IDS135]

[**] [1:472:5] ICMP redirect host [**]
[Classification: Potentially Bad Traffic] [Priority: 2]
12/10-03:25:47.832002 0:0:B4:98:21:B0 -> 0:55:D0:F1:DC:1B type:0x800 len:0x24E
192.168.2.30 -> 10.10.1.3 ICMP TTL:64 TOS:0xC0 ID:47288 IpLen:20 DgmLen:576
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.0.5
** ORIGINAL DATAGRAM DUMP:
10.10.1.3:80 -> 192.168.0.5:1463 TCP TTL:64 TOS:0x0 ID:52991 IpLen:20 DgmLen:1500 DF
Seq: 0x17DAFC51
(520 more bytes of original packet)
** END OF DUMP
[Xref => http://cve.mitre.org/cgi-bin/cvename.cgi?name=1999-0265][Xref =>
http://www.whitehats.com/info/IDS135]

[**] [1:472:5] ICMP redirect host [**]
[Classification: Potentially Bad Traffic] [Priority: 2]
12/10-03:25:51.005147 0:0:B4:98:21:B0 -> 0:55:D0:F1:DC:1B type:0x800 len:0x208
192.168.2.30 -> 10.10.1.3 ICMP TTL:64 TOS:0xC0 ID:47290 IpLen:20 DgmLen:506
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.0.5
** ORIGINAL DATAGRAM DUMP:
10.10.1.3:80 -> 192.168.0.5:1466 TCP TTL:64 TOS:0x0 ID:45805 IpLen:20 DgmLen:478 DF
Seq: 0x170C8D9A
(450 more bytes of original packet)
** END OF DUMP
[Xref => http://cve.mitre.org/cgi-bin/cvename.cgi?name=1999-0265][Xref =>
http://www.whitehats.com/info/IDS135]

[**] [1:472:5] ICMP redirect host [**]
[Classification: Potentially Bad Traffic] [Priority: 2]
12/10-04:33:08.098943 0:0:B4:98:21:B0 -> 0:55:D0:F1:DC:1B type:0x800 len:0x5A
192.168.2.30 -> 10.10.1.3 ICMP TTL:64 TOS:0xC0 ID:26239 IpLen:20 DgmLen:76
```

```
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.2.25
** ORIGINAL DATAGRAM DUMP:
10.10.1.3:22 -> 192.168.2.25:1130 TCP TTL:64 TOS:0x0 ID:0 IpLen:20 DgmLen:48 DF
Seq: 0xDB884557
(20 more bytes of original packet)
** END OF DUMP
[Xref => http://cve.mitre.org/cgi-bin/cvename.cgi?name=1999-0265][Xref =>
http://www.whitehats.com/info/IDS135]

[**] [1:472:5] ICMP redirect host [**]
[Classification: Potentially Bad Traffic] [Priority: 2]
12/10-04:33:58.593157 0:0:B4:98:21:B0 -> 0:55:D0:F1:DC:1B type:0x800 len:0x5A
192.168.2.30 -> 10.10.1.3 ICMP TTL:64 TOS:0xC0 ID:26246 IpLen:20 DgmLen:76
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.2.25
** ORIGINAL DATAGRAM DUMP:
10.10.1.3:22 -> 192.168.2.25:1131 TCP TTL:64 TOS:0x0 ID:0 IpLen:20 DgmLen:48 DF
Seq: 0xB131F2B
(20 more bytes of original packet)
** END OF DUMP
[Xref => http://cve.mitre.org/cgi-bin/cvename.cgi?name=1999-0265][Xref =>
http://www.whitehats.com/info/IDS135]

[**] [1:472:5] ICMP redirect host [**]
[Classification: Potentially Bad Traffic] [Priority: 2]
12/10-07:02:06.347845 0:0:B4:98:21:B0 -> 0:55:D0:F1:DC:1B type:0x800 len:0x5A
192.168.2.30 -> 10.10.1.5 ICMP TTL:64 TOS:0xC0 ID:62052 IpLen:20 DgmLen:76
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.2.25
** ORIGINAL DATAGRAM DUMP:
10.10.1.5:22 -> 192.168.2.25:1345 TCP TTL:64 TOS:0x0 ID:0 IpLen:20 DgmLen:48 DF
Seq: 0x587FA76C
(20 more bytes of original packet)
** END OF DUMP
[Xref => http://cve.mitre.org/cgi-bin/cvename.cgi?name=1999-0265][Xref =>
http://www.whitehats.com/info/IDS135]

[**] [1:472:5] ICMP redirect host [**]
[Classification: Potentially Bad Traffic] [Priority: 2]
12/10-07:02:32.361511 0:0:B4:98:21:B0 -> 0:55:D0:F1:DC:1B type:0x800 len:0x5A
192.168.2.30 -> 10.10.1.5 ICMP TTL:64 TOS:0xC0 ID:62058 IpLen:20 DgmLen:76
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.2.25
** ORIGINAL DATAGRAM DUMP:
10.10.1.5:22 -> 192.168.2.25:1347 TCP TTL:64 TOS:0x0 ID:0 IpLen:20 DgmLen:48 DF
Seq: 0x70C690D6
(20 more bytes of original packet)
** END OF DUMP
[Xref => http://cve.mitre.org/cgi-bin/cvename.cgi?name=1999-0265][Xref =>
http://www.whitehats.com/info/IDS135]

[**] [1:472:5] ICMP redirect host [**]
[Classification: Potentially Bad Traffic] [Priority: 2]
12/10-07:02:54.040474 0:0:B4:98:21:B0 -> 0:55:D0:F1:DC:1B type:0x800 len:0x5A
192.168.2.30 -> 10.10.1.5 ICMP TTL:64 TOS:0xC0 ID:62063 IpLen:20 DgmLen:76
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.2.25
** ORIGINAL DATAGRAM DUMP:
10.10.1.5:22 -> 192.168.2.25:1348 TCP TTL:64 TOS:0x0 ID:0 IpLen:20 DgmLen:48 DF
Seq: 0x84827577
(20 more bytes of original packet)
** END OF DUMP
[Xref => http://cve.mitre.org/cgi-bin/cvename.cgi?name=1999-0265][Xref =>
http://www.whitehats.com/info/IDS135]

[**] [1:472:5] ICMP redirect host [**]
[Classification: Potentially Bad Traffic] [Priority: 2]
12/10-07:05:23.271162 0:0:B4:98:21:B0 -> 0:55:D0:F1:DC:1B type:0x800 len:0x5A
192.168.2.30 -> 10.10.1.5 ICMP TTL:64 TOS:0xC0 ID:62067 IpLen:20 DgmLen:76
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.2.25
```

```
** ORIGINAL DATAGRAM DUMP:
10.10.1.5:80 -> 192.168.2.25:1351 TCP TTL:64 TOS:0x0 ID:0 IpLen:20 DgmLen:48 DF
Seq: 0xFC7832B
(20 more bytes of original packet)
** END OF DUMP
[Xref => http://cve.mitre.org/cgi-bin/cvename.cgi?name=1999-0265][Xref =>
http://www.whitehats.com/info/IDS135]

[**] [1:472:5] ICMP redirect host [**]
[Classification: Potentially Bad Traffic] [Priority: 2]
12/10-07:05:24.541795 0:0:B4:98:21:B0 -> 0:55:D0:F1:DC:1B type:0x800 len:0x52
192.168.2.30 -> 10.10.1.5 ICMP TTL:64 TOS:0xC0 ID:62069 IpLen:20 DgmLen:68
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.2.25
** ORIGINAL DATAGRAM DUMP:
10.10.1.5:80 -> 192.168.2.25:1352 TCP TTL:64 TOS:0x0 ID:9056 IpLen:20 DgmLen:40 DF
Seq: 0x10080A07
(12 more bytes of original packet)
** END OF DUMP
[Xref => http://cve.mitre.org/cgi-bin/cvename.cgi?name=1999-0265][Xref =>
http://www.whitehats.com/info/IDS135]

[**] [1:472:5] ICMP redirect host [**]
[Classification: Potentially Bad Traffic] [Priority: 2]
12/10-07:05:35.367546 0:0:B4:98:21:B0 -> 0:55:D0:F1:DC:1B type:0x800 len:0x24E
192.168.2.30 -> 10.10.1.5 ICMP TTL:64 TOS:0xC0 ID:62075 IpLen:20 DgmLen:576
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.2.25
** ORIGINAL DATAGRAM DUMP:
10.10.1.5:80 -> 192.168.2.25:1356 TCP TTL:64 TOS:0x0 ID:46541 IpLen:20 DgmLen:1500 DF
Seq: 0x13F93EAB
(520 more bytes of original packet)
** END OF DUMP
[Xref => http://cve.mitre.org/cgi-bin/cvename.cgi?name=1999-0265][Xref =>
http://www.whitehats.com/info/IDS135]

[**] [1:1141:11] WEB-MISC handler access [**]
[Classification: access to a potentially vulnerable web application] [Priority: 2]
12/10-07:05:36.752156 0:8:2:E1:27:AA -> 0:0:B4:98:21:B0 type:0x800 len:0x1B9
192.168.2.25:1354 -> 10.10.1.5:80 TCP TTL:128 TOS:0x0 ID:4067 IpLen:20 DgmLen:427 DF
***AP*** Seq: 0xB33FEC8B  Ack: 0x131844DC  Win: 0xFC41  TcpLen: 20
[Xref => http://cgi.nessus.org/plugins/dump.php3?id=10100][Xref =>
http://cve.mitre.org/cgi-bin/cvename.cgi?name=1999-0148][Xref =>
http://www.securityfocus.com/bid/380][Xref => http://www.whitehats.com/info/IDS235]

[**] [1:472:5] ICMP redirect host [**]
[Classification: Potentially Bad Traffic] [Priority: 2]
12/10-07:10:16.388189 0:0:B4:98:21:B0 -> 0:55:D0:F1:DC:1B type:0x800 len:0x5A
192.168.2.30 -> 10.10.1.5 ICMP TTL:64 TOS:0xC0 ID:62080 IpLen:20 DgmLen:76
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.0.5
** ORIGINAL DATAGRAM DUMP:
10.10.1.5:80 -> 192.168.0.5:1394 TCP TTL:64 TOS:0x0 ID:0 IpLen:20 DgmLen:48 DF
Seq: 0x219C3954
(20 more bytes of original packet)
** END OF DUMP
[Xref => http://cve.mitre.org/cgi-bin/cvename.cgi?name=1999-0265][Xref =>
http://www.whitehats.com/info/IDS135]

[**] [1:472:5] ICMP redirect host [**]
[Classification: Potentially Bad Traffic] [Priority: 2]
12/10-07:10:24.155715 0:0:B4:98:21:B0 -> 0:55:D0:F1:DC:1B type:0x800 len:0x24E
192.168.2.30 -> 10.10.1.5 ICMP TTL:64 TOS:0xC0 ID:62083 IpLen:20 DgmLen:576
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.0.5
** ORIGINAL DATAGRAM DUMP:
10.10.1.5:80 -> 192.168.0.5:1398 TCP TTL:64 TOS:0x0 ID:56881 IpLen:20 DgmLen:1500 DF
Seq: 0x285A0AF4
(520 more bytes of original packet)
** END OF DUMP
```

```
[Xref => http://cve.mitre.org/cgi-bin/cvename.cgi?name=1999-0265][Xref =>
http://www.whitehats.com/info/IDS135]

[**] [1:472:5] ICMP redirect host [**]
[Classification: Potentially Bad Traffic] [Priority: 2]
12/10-07:10:35.049931 0:0:B4:98:21:B0 -> 0:55:D0:F1:DC:1B type:0x800 len:0x5A
192.168.2.30 -> 10.10.1.5 ICMP TTL:64 TOS:0xC0 ID:62084 IpLen:20 DgmLen:76
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.0.5
** ORIGINAL DATAGRAM DUMP:
10.10.1.5:80 -> 192.168.0.5:1400 TCP TTL:64 TOS:0x0 ID:0 IpLen:20 DgmLen:48 DF
Seq: 0x32F36D12
(20 more bytes of original packet)
** END OF DUMP
[Xref => http://cve.mitre.org/cgi-bin/cvename.cgi?name=1999-0265][Xref =>
http://www.whitehats.com/info/IDS135]

[**] [1:472:5] ICMP redirect host [**]
[Classification: Potentially Bad Traffic] [Priority: 2]
12/10-07:11:30.758547 0:0:B4:98:21:B0 -> 0:55:D0:F1:DC:1B type:0x800 len:0x5A
192.168.2.30 -> 10.10.1.5 ICMP TTL:64 TOS:0xC0 ID:62085 IpLen:20 DgmLen:76
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.0.5
** ORIGINAL DATAGRAM DUMP:
10.10.1.5:80 -> 192.168.0.5:1409 TCP TTL:64 TOS:0x0 ID:0 IpLen:20 DgmLen:48 DF
Seq: 0x681F9910
(20 more bytes of original packet)
** END OF DUMP
[Xref => http://cve.mitre.org/cgi-bin/cvename.cgi?name=1999-0265][Xref =>
http://www.whitehats.com/info/IDS135]

[**] [1:895:8] WEB-CGI redirect access [**]
[Classification: Attempted Information Leak] [Priority: 2]
12/10-07:11:39.892292 0:8:2:E1:27:AA -> 0:0:B4:98:21:B0 type:0x800 len:0x2E6
192.168.0.5:1411 -> 10.10.1.5:80 TCP TTL:128 TOS:0x0 ID:5933 IpLen:20 DgmLen:728 DF
***AP*** Seq: 0xA9BE804D  Ack: 0x6FE9C253  Win: 0xFFFF  TcpLen: 20
[Xref => http://cve.mitre.org/cgi-bin/cvename.cgi?name=2000-0382][Xref =>
http://www.securityfocus.com/bid/1179]

[**] [1:895:8] WEB-CGI redirect access [**]
[Classification: Attempted Information Leak] [Priority: 2]
12/10-07:11:52.767158 0:8:2:E1:27:AA -> 0:0:B4:98:21:B0 type:0x800 len:0x306
192.168.0.5:1413 -> 10.10.1.5:80 TCP TTL:128 TOS:0x0 ID:5981 IpLen:20 DgmLen:760 DF
***AP*** Seq: 0x57D9768C  Ack: 0x7C03B6DE  Win: 0xFFFF  TcpLen: 20
[Xref => http://cve.mitre.org/cgi-bin/cvename.cgi?name=2000-0382][Xref =>
http://www.securityfocus.com/bid/1179]

[**] [1:469:4] ICMP PING NMAP [**]
[Classification: Attempted Information Leak] [Priority: 2]
12/11-00:38:16.056092 0:8:2:E1:27:AA -> 0:0:B4:98:21:B0 type:0x800 len:0x3C
192.168.2.16 -> 10.10.1.2 ICMP TTL:48 TOS:0x0 ID:42521 IpLen:20 DgmLen:28
Type:8  Code:0  ID:62073   Seq:45584  ECHO
[Xref => http://www.whitehats.com/info/IDS162]

[**] [1:1420:13] SNMP trap tcp [**]
[Classification: Attempted Information Leak] [Priority: 2]
12/11-00:38:16.400032 0:8:2:E1:27:AA -> 0:0:B4:98:21:B0 type:0x800 len:0x3C
192.168.2.16:34592 -> 10.10.1.2:162 TCP TTL:55 TOS:0x0 ID:3799 IpLen:20 DgmLen:40
******S* Seq: 0x789720AA  Ack: 0x0  Win: 0x1000  TcpLen: 20
[Xref => http://cve.mitre.org/cgi-bin/cvename.cgi?name=2002-0013][Xref =>
http://cve.mitre.org/cgi-bin/cvename.cgi?name=2002-0012][Xref =>
http://www.securityfocus.com/bid/4132][Xref => http://www.securityfocus.com/bid/4089]
[Xref => http://www.securityfocus.com/bid/4088]

[**] [1:1418:13] SNMP request tcp [**]
[Classification: Attempted Information Leak] [Priority: 2]
12/11-00:38:16.603968 0:8:2:E1:27:AA -> 0:0:B4:98:21:B0 type:0x800 len:0x3C
192.168.2.16:34592 -> 10.10.1.2:161 TCP TTL:53 TOS:0x0 ID:38721 IpLen:20 DgmLen:40
```

```
******S* Seq: 0x789720AA  Ack: 0x0  Win: 0x800  TcpLen: 20
[Xref => http://cve.mitre.org/cgi-bin/cvename.cgi?name=2002-0013][Xref =>
http://cve.mitre.org/cgi-bin/cvename.cgi?name=2002-0012][Xref =>
http://www.securityfocus.com/bid/4132][Xref => http://www.securityfocus.com/bid/4089]
[Xref => http://www.securityfocus.com/bid/4088]

[**] [1:472:5] ICMP redirect host [**]
[Classification: Potentially Bad Traffic] [Priority: 2]
12/11-00:38:50.424780 0:0:B4:98:21:B0 -> 0:55:D0:F1:DC:1B type:0x800 len:0x52
192.168.2.30 -> 10.10.1.2 ICMP TTL:64 TOS:0xC0 ID:17264 IpLen:20 DgmLen:68
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.2.16
** ORIGINAL DATAGRAM DUMP:
10.10.1.2:3306 -> 192.168.2.16:53814 TCP TTL:64 TOS:0x0 ID:0 IpLen:20 DgmLen:40 DF
Seq: 0x0
(12 more bytes of original packet)
** END OF DUMP
[Xref => http://cve.mitre.org/cgi-bin/cvename.cgi?name=1999-0265][Xref =>
http://www.whitehats.com/info/IDS135]

[**] [1:472:5] ICMP redirect host [**]
[Classification: Potentially Bad Traffic] [Priority: 2]
12/11-00:39:04.831516 0:0:B4:98:21:B0 -> 0:55:D0:F1:DC:1B type:0x800 len:0x52
192.168.2.30 -> 10.10.1.2 ICMP TTL:64 TOS:0xC0 ID:17265 IpLen:20 DgmLen:68
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.2.16
** ORIGINAL DATAGRAM DUMP:
10.10.1.2:3306 -> 192.168.2.16:53815 TCP TTL:64 TOS:0x0 ID:0 IpLen:20 DgmLen:40 DF
Seq: 0x0
(12 more bytes of original packet)
** END OF DUMP
[Xref => http://cve.mitre.org/cgi-bin/cvename.cgi?name=1999-0265][Xref =>
http://www.whitehats.com/info/IDS135]

[**] [1:472:5] ICMP redirect host [**]
[Classification: Potentially Bad Traffic] [Priority: 2]
12/10-04:59:17.202551 0:0:B4:98:21:B0 -> 0:55:D0:F1:DC:1B type:0x800 len:0x5A
192.168.2.30 -> 10.10.1.3 ICMP TTL:64 TOS:0xC0 ID:16461 IpLen:20 DgmLen:76
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.1.13
** ORIGINAL DATAGRAM DUMP:
10.10.1.3:80 -> 192.168.1.13:1173 TCP TTL:64 TOS:0x0 ID:0 IpLen:20 DgmLen:48 DF
Seq: 0x9689FA3A
(20 more bytes of original packet)
** END OF DUMP
[Xref => http://cve.mitre.org/cgi-bin/cvename.cgi?name=1999-0265][Xref =>
http://www.whitehats.com/info/IDS135]

[**] [1:472:5] ICMP redirect host [**]
[Classification: Potentially Bad Traffic] [Priority: 2]
12/10-04:59:17.324732 0:0:B4:98:21:B0 -> 0:55:D0:F1:DC:1B type:0x800 len:0x5A
192.168.2.30 -> 10.10.1.3 ICMP TTL:64 TOS:0xC0 ID:16462 IpLen:20 DgmLen:76
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.1.13
** ORIGINAL DATAGRAM DUMP:
10.10.1.3:80 -> 192.168.1.13:1175 TCP TTL:64 TOS:0x0 ID:0 IpLen:20 DgmLen:48 DF
Seq: 0x969AC0FF
(20 more bytes of original packet)
** END OF DUMP
[Xref => http://cve.mitre.org/cgi-bin/cvename.cgi?name=1999-0265][Xref =>
http://www.whitehats.com/info/IDS135]

[**] [1:472:5] ICMP redirect host [**]
[Classification: Potentially Bad Traffic] [Priority: 2]
12/10-04:59:20.841797 0:0:B4:98:21:B0 -> 0:55:D0:F1:DC:1B type:0x800 len:0x5A
192.168.2.30 -> 10.10.1.3 ICMP TTL:64 TOS:0xC0 ID:16467 IpLen:20 DgmLen:76
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.1.13
** ORIGINAL DATAGRAM DUMP:
10.10.1.3:80 -> 192.168.1.13:1179 TCP TTL:64 TOS:0x0 ID:0 IpLen:20 DgmLen:48 DF
Seq: 0x99ACD224
```

```
(20 more bytes of original packet)
** END OF DUMP
[Xref => http://cve.mitre.org/cgi-bin/cvename.cgi?name=1999-0265][Xref =>
http://www.whitehats.com/info/IDS135]

[**] [1:1141:11] WEB-MISC handler access [**]
[Classification: access to a potentially vulnerable web application] [Priority: 2]
12/10-04:59:30.635958 0:8:2:E1:27:AA -> 0:0:B4:98:21:B0 type:0x800 len:0x1B9
192.168.1.13:1180 -> 10.10.1.3:80 TCP TTL:128 TOS:0x0 ID:1413 IpLen:20 DgmLen:427 DF
***AP*** Seq: 0xC8B30EC2  Ack: 0x9968151B  Win: 0xFC41  TcpLen: 20
[Xref => http://cgi.nessus.org/plugins/dump.php3?id=10100][Xref =>
http://cve.mitre.org/cgi-bin/cvename.cgi?name=1999-0148][Xref =>
http://www.securityfocus.com/bid/380][Xref => http://www.whitehats.com/info/IDS235]

[**] [1:472:5] ICMP redirect host [**]
[Classification: Potentially Bad Traffic] [Priority: 2]
12/11-15:06:44.508449 0:0:B4:98:21:B0 -> 0:55:D0:F1:DC:1B type:0x800 len:0xAA
192.168.2.30 -> 10.10.1.2 ICMP TTL:64 TOS:0xC0 ID:21848 IpLen:20 DgmLen:156
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.1.13
** ORIGINAL DATAGRAM DUMP:
10.10.1.2:25 -> 192.168.1.13:1158 TCP TTL:64 TOS:0x0 ID:62725 IpLen:20 DgmLen:128 DF
Seq: 0xB58FB249
(100 more bytes of original packet)
** END OF DUMP
[Xref => http://cve.mitre.org/cgi-bin/cvename.cgi?name=1999-0265][Xref =>

http://www.whitehats.com/info/IDS135]
```

ii) Normal Activities Logs using *snort* software in folder `/var/log/snort/alert`

The other hand, there is source IP address of intrusion activities doing normal activities. They all in folder `/var/log/snort/snort.log.*`

```
12/10-07:10:07.947573 192.168.2.30 -> 10.10.1.5
ICMP TTL:64 TOS:0xC0 ID:62077 IpLen:20 DgmLen:576
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.0.5
** ORIGINAL DATAGRAM DUMP:
10.10.1.5:80 -> 192.168.0.5:1384
TCP TTL:64 TOS:0x0 ID:10034 IpLen:20 DgmLen:1500 DF
Seq: 0x195C194B
(520 more bytes of original packet)
** END OF DUMP
=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+

12/10-07:10:13.038867 192.168.2.30 -> 10.10.1.5
ICMP TTL:64 TOS:0xC0 ID:62079 IpLen:20 DgmLen:68
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.0.5
** ORIGINAL DATAGRAM DUMP:
10.10.1.5:80 -> 192.168.0.5:1391
TCP TTL:64 TOS:0x0 ID:50455 IpLen:20 DgmLen:40 DF
Seq: 0x19A3336C
(12 more bytes of original packet)
** END OF DUMP
=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+

12/10-07:10:15.038869 192.168.2.30 -> 10.10.1.5
ICMP TTL:64 TOS:0xC0 ID:62079 IpLen:20 DgmLen:68
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.0.5
** ORIGINAL DATAGRAM DUMP:
10.10.1.5:80 -> 192.168.0.5:1393
TCP TTL:64 TOS:0x0 ID:50455 IpLen:20 DgmLen:40 DF
Seq: 0x19A3336C
(12 more bytes of original packet)
** END OF DUMP
=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+


12/10-07:11:30.844676 192.168.2.30 -> 10.10.1.5
ICMP TTL:64 TOS:0xC0 ID:62086 IpLen:20 DgmLen:68
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.0.5
** ORIGINAL DATAGRAM DUMP:
10.10.1.5:80 -> 192.168.0.5:1409
TCP TTL:64 TOS:0x0 ID:47038 IpLen:20 DgmLen:40 DF
Seq: 0x681F9B1D
(12 more bytes of original packet)
** END OF DUMP
=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+

12/10-07:11:43.212440 192.168.2.30 -> 10.10.1.5
ICMP TTL:64 TOS:0xC0 ID:62092 IpLen:20 DgmLen:576
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.0.5
** ORIGINAL DATAGRAM DUMP:
10.10.1.5:80 -> 192.168.0.5:1411
TCP TTL:64 TOS:0x0 ID:62918 IpLen:20 DgmLen:1500 DF
Seq: 0x6FE9C253
(520 more bytes of original packet)
** END OF DUMP
=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+
12/10-07:12:03.396917 192.168.0.5:1413 -> 10.10.1.5:80
TCP TTL:128 TOS:0x0 ID:6010 IpLen:20 DgmLen:761 DF
***AP*** Seq: 0x57D97B93  Ack: 0x7C03CAC7  Win: 0xFFF2  TcpLen: 20
=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+

12/11-00:43:13.223665 192.168.2.30 -> 10.10.1.2
ICMP TTL:64 TOS:0xC0 ID:17267 IpLen:20 DgmLen:576
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.2.16
** ORIGINAL DATAGRAM DUMP:
10.10.1.2:80 -> 192.168.2.16:49869
TCP TTL:64 TOS:0x0 ID:58872 IpLen:20 DgmLen:1500 DF
Seq: 0x63587A97
(520 more bytes of original packet)
** END OF DUMP
=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+

12/11-00:43:57.140425 192.168.2.30 -> 10.10.1.2
ICMP TTL:64 TOS:0xC0 ID:17271 IpLen:20 DgmLen:80
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.2.16
** ORIGINAL DATAGRAM DUMP:
10.10.1.2:80 -> 192.168.2.16:49870
TCP TTL:64 TOS:0x0 ID:32847 IpLen:20 DgmLen:52 DF
Seq: 0x871A8285
(24 more bytes of original packet)
** END OF DUMP
=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+

12/11-00:44:00.634244 192.168.2.30 -> 10.10.1.2
ICMP TTL:64 TOS:0xC0 ID:17272 IpLen:20 DgmLen:576
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.2.16
** ORIGINAL DATAGRAM DUMP:
10.10.1.2:80 -> 192.168.2.16:49871
TCP TTL:64 TOS:0x0 ID:12694 IpLen:20 DgmLen:1500 DF
Seq: 0x8CA8C85C
(520 more bytes of original packet)
** END OF DUMP
=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+

12/11-00:44:12.642863 192.168.2.30 -> 10.10.1.2
ICMP TTL:64 TOS:0xC0 ID:17274 IpLen:20 DgmLen:576
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.2.16
** ORIGINAL DATAGRAM DUMP:
10.10.1.2:80 -> 192.168.2.16:49872
TCP TTL:64 TOS:0x0 ID:65005 IpLen:20 DgmLen:1500 DF
Seq: 0x93BD0881
(520 more bytes of original packet)
** END OF DUMP
=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+

12/12-07:01:58.825394 192.168.2.30 -> 10.10.1.3
ICMP TTL:64 TOS:0xC0 ID:43929 IpLen:20 DgmLen:76
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.0.5
** ORIGINAL DATAGRAM DUMP:
10.10.1.3:80 -> 192.168.0.5:1181
TCP TTL:64 TOS:0x0 ID:0 IpLen:20 DgmLen:48 DF
Seq: 0xDEE28FFC
(20 more bytes of original packet)
** END OF DUMP
=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+

12/12-07:02:23.383762 192.168.2.30 -> 10.10.1.3
ICMP TTL:64 TOS:0xC0 ID:43932 IpLen:20 DgmLen:76
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.0.5
** ORIGINAL DATAGRAM DUMP:
10.10.1.3:80 -> 192.168.0.5:1183
```

```
TCP TTL:64 TOS:0x0 ID:0 IpLen:20 DgmLen:48 DF
Seq: 0xF5EEEBB2
(20 more bytes of original packet)
** END OF DUMP
=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+

12/12-07:02:28.429310 192.168.2.30 -> 10.10.1.3
ICMP TTL:64 TOS:0xC0 ID:43933 IpLen:20 DgmLen:68
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.0.5
** ORIGINAL DATAGRAM DUMP:
10.10.1.3:80 -> 192.168.0.5:1185
TCP TTL:64 TOS:0x0 ID:10639 IpLen:20 DgmLen:40 DF
Seq: 0xF5EF1F10
(12 more bytes of original packet)
** END OF DUMP
=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+

12/12-07:13:11.164337 192.168.2.30 -> 10.10.1.3
ICMP TTL:64 TOS:0xC0 ID:43934 IpLen:20 DgmLen:76
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.1.13
** ORIGINAL DATAGRAM DUMP:
10.10.1.3:22 -> 192.168.1.13:1203
TCP TTL:64 TOS:0x0 ID:0 IpLen:20 DgmLen:48 DF
Seq: 0x546B278A
(20 more bytes of original packet)
** END OF DUMP
=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+

12/12-07:15:26.465507 192.168.2.30 -> 10.10.1.3
ICMP TTL:64 TOS:0xC0 ID:43944 IpLen:20 DgmLen:68
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.1.13
** ORIGINAL DATAGRAM DUMP:
10.10.1.3:22 -> 192.168.1.13:1204
TCP TTL:64 TOS:0x0 ID:5502 IpLen:20 DgmLen:40 DF
Seq: 0xD25DB00C
(12 more bytes of original packet)
** END OF DUMP
=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+

12/12-07:34:30.926554 192.168.2.30 -> 10.10.1.5
ICMP TTL:64 TOS:0xD0 ID:8643 IpLen:20 DgmLen:68
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.1.13
** ORIGINAL DATAGRAM DUMP:
10.10.1.5:22 -> 192.168.1.13:1220
TCP TTL:64 TOS:0x10 ID:51116 IpLen:20 DgmLen:40 DF
Seq: 0xDCDC1009
(12 more bytes of original packet)
** END OF DUMP
=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+

12/12-09:42:01.762837 192.168.2.30 -> 10.10.1.3
ICMP TTL:64 TOS:0xC0 ID:14947 IpLen:20 DgmLen:76
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.1.13
** ORIGINAL DATAGRAM DUMP:
10.10.1.3:80 -> 192.168.1.13:1419
TCP TTL:64 TOS:0x0 ID:0 IpLen:20 DgmLen:48 DF
Seq: 0xBECBA19C
(20 more bytes of original packet)
** END OF DUMP
=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+

12/12-09:42:22.874992 192.168.2.30 -> 10.10.1.3
ICMP TTL:64 TOS:0xC0 ID:14953 IpLen:20 DgmLen:76
Type:5  Code:1  REDIRECT HOST NEW GW: 192.168.1.13
** ORIGINAL DATAGRAM DUMP:
10.10.1.3:80 -> 192.168.1.13:1423
```

```
TCP TTL:64 TOS:0x0 ID:0 IpLen:20 DgmLen:48 DF
Seq: 0xD2EEF1FA
(20 more bytes of original packet)
** END OF DUMP
=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+
```

APPENDIX B

MANUAL AND LISTING PROGRAM

1. Extract of File `nips-nids2s3.tar.gz`
   ```
   # tar xvzf nips-nids2s3.tar.gz
   ```
2. Change to the directory `nips-nids2s3` :
   ```
   # cd nips-nids2s3
   ```
3. Compile :
   ```
   # make
   ```
4. Before run program, to see the rule in firewall *iptables* :
   ```
   # iptables -nL
   ```
5. If there is rules, flush the rules :
   ```
   # iptables -F
   ```
6. Run program using command :
   ```
   #./syh -a sdpd
   ```
7. See again rules at iptables using command :
   ```
   #iptables -nL
   ```

Note :

- This software, dataset for data training in file 'data' at directory `nips-nid2s3`. Change the content from in file 'data' to another data training then run its program and see again the result into *iptables* firewall rules.
- This software, if using Slackware OS file execute `iptables` into directory `/usr/sbin/iptables`, For another distro Linux like Fedora and Ubuntu, file execute `iptables` into directory `/sbin/iptables`, so must change path at content source code in `ipt.c` file and replace become `/sbin/iptables` and then to compile again.

entr.h

```
#ifndef _ENTR_H
#define _ENTR_H

#include "lst.h"

float entr_smpl(struct lst_pkt_t *);
float entr_attr(struct lst_grp_intr_t *);
float entr_attr2(struct lst_grp_intr2_t *);

#endif /* _ENTR_H */

/* vim:ts=4:sw=4:tw=80:fdm=marker:cin:
 */
```

entr.c

```
#include <stdio.h>
#include <math.h>
#include "lst.h"

/* entr() {{{ */
float entr(float yes, float no)
{
        float sum;

        if ((yes == 0) || (no == 0)) {
                return 0;
        }
        sum = yes + no;
        return (- (yes / sum) * log2f(yes / sum) - (no / sum) * log2f(no / sum));
}
/* }}} */
/* entr_smpl() {{{ */
float entr_smpl(struct lst_pkt_t *head)
{
        struct lst_pkt_t *walk;
        unsigned int intr_y = 0, intr_n = 0;

        walk = head;
        while (walk != NULL) {
                if (walk->intrusion == 0) {
                        intr_n++;
                } else {
                        intr_y++;
                }
                walk = walk->next;
        }
        return entr(intr_y, intr_n);
}
/* }}} */
/* entr_attr() {{{ */
float entr_attr(struct lst_grp_intr_t *head)
{
        struct lst_grp_intr_t *walk;
        float sum, ret;

        /* calculate sample sum */
        sum = 0;
        walk = head;
        while (walk != NULL) {
                sum += walk->yes + walk->no;
                walk = walk->next;
        }

        walk = head;
        ret = 0;
        while (walk != NULL) {
                ret += ((walk->yes + walk->no) / sum) * entr(walk->yes, walk->no);
                walk = walk->next;
        }
        return ret;
}
/* }}} */
/* entr_attr2() {{{ */
float entr_attr2(struct lst_grp_intr2_t *head)
{
        struct lst_grp_intr2_t *walk;
        float sum, ret;
        /* calculate sample sum */
        sum = 0;
        walk = head;
        while (walk != NULL) {
                sum += walk->yes + walk->no;
                walk = walk->next;
        }

        walk = head;
        ret = 0;
        while (walk != NULL) {
                ret += ((walk->yes + walk->no) / sum) * entr(walk->yes, walk->no);
                walk = walk->next;
        }
        return ret;
}
/* }}} */

/* vim:ts=4:sw=4:tw=80:fdm=marker:cin:
 */
```

grp.c

```
#include <stdio.h>
#include "lst.h"
#include "pkt.h"

/* grp_intr_src() {{{ */
void grp_intr_src(struct lst_pkt_t *pkt_head,
            struct lst_grp_intr_t **grp_src_head,
            struct lst_grp_intr_t **grp_src_tail)
{
        struct lst_pkt_t *pkt_walk;
        struct lst_grp_intr_t *grp_src_tmp;

        lst_grp_intr_init(grp_src_head, grp_src_tail);
        pkt_walk = pkt_head;
        while (pkt_walk != NULL) {
                grp_src_tmp = lst_grp_intr_find(*grp_src_head, pkt_walk->src);
                if (pkt_walk->intrusion == 1) {
                        if (grp_src_tmp == NULL) {
                                lst_grp_intr_add(grp_src_head, grp_src_tail,
                                        pkt_walk->src, 1, 0);
                        } else {
                                grp_src_tmp->yes++;
                        }
                } else {
                        if (grp_src_tmp == NULL) {
                                lst_grp_intr_add(grp_src_head, grp_src_tail,
                                        pkt_walk->src, 0, 1);
                        } else {
                                grp_src_tmp->no++;
                        }
                }
                pkt_walk = pkt_walk->next;
        }
}
/* }}} */
/* grp_intr_dst() {{{ */
void grp_intr_dst(struct lst_pkt_t *pkt_head,
            struct lst_grp_intr_t **grp_dst_head,
            struct lst_grp_intr_t **grp_dst_tail)
{
        struct lst_pkt_t *pkt_walk;
        struct lst_grp_intr_t *grp_dst_tmp;

        lst_grp_intr_init(grp_dst_head, grp_dst_tail);
        pkt_walk = pkt_head;
        while (pkt_walk != NULL) {
                grp_dst_tmp = lst_grp_intr_find(*grp_dst_head, pkt_walk->dst);
                if (pkt_walk->intrusion == 1) {
                        if (grp_dst_tmp == NULL) {
                                lst_grp_intr_add(grp_dst_head, grp_dst_tail,
                                        pkt_walk->dst, 1, 0);
                        } else {
                                grp_dst_tmp->yes++;
                        }
                } else {
                        if (grp_dst_tmp == NULL) {
                                lst_grp_intr_add(grp_dst_head, grp_dst_tail,
                                        pkt_walk->dst, 0, 1);
                        } else {
                                grp_dst_tmp->no++;
                        }
                }
```

```
			pkt_walk = pkt_walk->next;
		}
}
/* }}} */
/* grp_intr_proto() {{{ */
void grp_intr_proto(struct lst_pkt_t *pkt_head,
		struct lst_grp_intr_t **grp_proto_head,
		struct lst_grp_intr_t **grp_proto_tail)
{
		struct lst_pkt_t *pkt_walk;
		struct lst_grp_intr_t *grp_proto_tmp;

		lst_grp_intr_init(grp_proto_head, grp_proto_tail);
		pkt_walk = pkt_head;
		while (pkt_walk != NULL) {
			grp_proto_tmp = lst_grp_intr_find(*grp_proto_head, pkt_walk->proto);
			if (pkt_walk->intrusion == 1) {
				if (grp_proto_tmp == NULL) {
					lst_grp_intr_add(grp_proto_head, grp_proto_tail,
						pkt_walk->proto, 1, 0);
				} else {
					grp_proto_tmp->yes++;
				}
			} else {
				if (grp_proto_tmp == NULL) {
					lst_grp_intr_add(grp_proto_head, grp_proto_tail,
						pkt_walk->proto, 0, 1);
				} else {
					grp_proto_tmp->no++;
				}
			}
			pkt_walk = pkt_walk->next;
		}
}
/* }}} */
/* grp_intr_sport() {{{ */
void grp_intr_sport(struct lst_pkt_t *pkt_head,
		struct lst_grp_intr_t **grp_sport_head,
		struct lst_grp_intr_t **grp_sport_tail)
{
		struct lst_pkt_t *pkt_walk;
		struct lst_grp_intr_t *grp_sport_tmp;

		lst_grp_intr_init(grp_sport_head, grp_sport_tail);
		pkt_walk = pkt_head;
		while (pkt_walk != NULL) {
			grp_sport_tmp = lst_grp_intr_find(*grp_sport_head, pkt_walk->sport);
			if (pkt_walk->intrusion == 1) {
				if (grp_sport_tmp == NULL) {
					lst_grp_intr_add(grp_sport_head, grp_sport_tail,
						pkt_walk->sport, 1, 0);
				} else {
					grp_sport_tmp->yes++;
				}
			} else {
				if (grp_sport_tmp == NULL) {
					lst_grp_intr_add(grp_sport_head, grp_sport_tail,
						pkt_walk->sport, 0, 1);
				} else {
					grp_sport_tmp->no++;
				}
			}
			pkt_walk = pkt_walk->next;
		}
}
```

```
/* }}} */
/* grp_intr_dport() {{{ */
void grp_intr_dport(struct lst_pkt_t *pkt_head,
                struct lst_grp_intr_t **grp_dport_head,
                struct lst_grp_intr_t **grp_dport_tail)
{
        struct lst_pkt_t *pkt_walk;
        struct lst_grp_intr_t *grp_dport_tmp;

        lst_grp_intr_init(grp_dport_head, grp_dport_tail);
        pkt_walk = pkt_head;
        while (pkt_walk != NULL) {
                grp_dport_tmp = lst_grp_intr_find(*grp_dport_head, pkt_walk->dport);
                if (pkt_walk->intrusion == 1) {
                        if (grp_dport_tmp == NULL) {
                                lst_grp_intr_add(grp_dport_head, grp_dport_tail,
                                          pkt_walk->dport, 1, 0);
                        } else {
                                grp_dport_tmp->yes++;
                        }
                } else {
                        if (grp_dport_tmp == NULL) {
                                lst_grp_intr_add(grp_dport_head, grp_dport_tail,
                                          pkt_walk->dport, 0, 1);
                        } else {
                                grp_dport_tmp->no++;
                        }
                }
                pkt_walk = pkt_walk->next;
        }
}
/* }}} */
/* grp_intr_proto_dport() {{{ */
void grp_intr_proto_dport(struct lst_pkt_t *pkt_head,
                struct lst_grp_intr2_t **grp_proto_dport_head,
                struct lst_grp_intr2_t **grp_proto_dport_tail)
{
        struct lst_pkt_t *pkt_walk;
        struct lst_grp_intr2_t *grp_proto_dport_tmp;

        lst_grp_intr2_init(grp_proto_dport_head, grp_proto_dport_tail);
        pkt_walk = pkt_head;
        while (pkt_walk != NULL) {
                grp_proto_dport_tmp = lst_grp_intr2_find(*grp_proto_dport_head,
                                        pkt_walk->proto,

         pkt_walk->dport);
                if (pkt_walk->intrusion == 1) {
                        if (grp_proto_dport_tmp == NULL) {
                                lst_grp_intr2_add(grp_proto_dport_head, grp_proto_dport_tail,
                                          pkt_walk->proto, pkt_walk->dport, 1, 0);
                        } else {
                                grp_proto_dport_tmp->yes++;
                        }
                } else {
                        if (grp_proto_dport_tmp == NULL) {
                                lst_grp_intr2_add(grp_proto_dport_head, grp_proto_dport_tail,
                                          pkt_walk->proto, pkt_walk->dport, 0, 1);
                        } else {
                                grp_proto_dport_tmp->no++;
                        }
                }
                pkt_walk = pkt_walk->next;
        }
}
```

id3.c

```
#include <stdio.h>
#include "lst.h"
#include "pkt.h"
#include "grp.h"
#include "ipt.h"
#include "entr.h"

/* id3() {{{ */
void id3(char level, struct lst_pkt_t *pkt_head, char shift, unsigned int src,
                        unsigned int dst, unsigned int proto, unsigned int dport)
{
        /* vars {{{ */
        struct lst_grp_intr_t *grp_src_head = NULL,
                                                        *grp_src_tail,
                                                        *grp_dst_head = NULL,
                                                        *grp_dst_tail,
                                                        *grp_proto_head = NULL,
                                                        *grp_proto_tail,
                                                        *grp_cmpl_head = NULL,
                                                        *grp_cmpl_tail,
                                                        *grp_walk;
        struct lst_pkt_t *l_pkt_head = NULL,
                                                *l_pkt_tail;
        float entr_s,
                entr_src,
                entr_dst,
                entr_proto,
                gain_src,
                gain_dst,
                gain_proto;
        char  tmp;
        /* }}} */
        if (level == 0) { /* {{{ */
                /* grouping {{{ */
                grp_intr_src(pkt_head, &grp_src_head, &grp_src_tail);
                grp_intr_dst(pkt_head, &grp_dst_head, &grp_dst_tail);
                grp_intr_proto(pkt_head, &grp_proto_head, &grp_proto_tail);
                /* }}} */
                /* calculate entropy and gain {{{ */
                entr_s     = entr_smpl(pkt_head);
                entr_src   = entr_attr(grp_src_head);
                entr_dst   = entr_attr(grp_dst_head);
                entr_proto = entr_attr(grp_proto_head);
                gain_src   = entr_s - entr_src;
                gain_dst   = entr_s - entr_dst;
                gain_proto = entr_s - entr_proto;
                /* }}} */
                if ((gain_src > gain_dst) && (gain_src > gain_proto)) {
                        /* gain source is higest {{{ */
                        grp_walk = grp_src_head;
                        while (grp_walk != NULL) {
                                tmp = pkt_filter(pkt_head, grp_walk->data, 0, 0, 0, 0,
                                        &l_pkt_head, &l_pkt_tail);
                                if (tmp == PKT_ALL_NORM) {
                                        /* pruning / ignore */
                                } else if (tmp == PKT_ALL_INTR) {
                                        ipt_blk(grp_walk->data, 0, 0, 0, 0);
                                } else {
                                        id3(1, l_pkt_head, 1, grp_walk->data, 0, 0, 0);
                                }
                                grp_walk = grp_walk->next;
                        }
                        /* }}} */
                } else if ((gain_dst > gain_src) && (gain_dst > gain_proto)) {
                        /* gain destination is higest {{{ */
                        grp_walk = grp_dst_head;
                        while (grp_walk != NULL) {
                                tmp = pkt_filter(pkt_head, 0, grp_walk->data, 0, 0, 0,
                                        &l_pkt_head, &l_pkt_tail);
                                if (tmp == PKT_ALL_NORM) {
                                        /* pruning / ignore */
                                } else if (tmp == PKT_ALL_INTR) {
                                        ipt_blk(0, grp_walk->data, 0, 0, 0);
                                } else {
                                        id3(1, l_pkt_head, 2, 0, grp_walk->data, 0, 0);
                                }
                                grp_walk = grp_walk->next;
                        }
                        /* }}} */
                } else {
                        /* gain protocol is higest {{{ */
                        grp_walk = grp_proto_head;
                        while (grp_walk != NULL) {
                                tmp = pkt_filter(pkt_head, 0, 0, grp_walk->data, 0, 0,
                                        &l_pkt_head, &l_pkt_tail);
                                if (tmp == PKT_ALL_NORM) {
                                        /* pruning / ignore */
                                } else if (tmp == PKT_ALL_INTR) {
                                        ipt_blk(0, 0, grp_walk->data, 0, 0);
                                } else {
                                        id3(1, l_pkt_head, 4, 0, 0, grp_walk->data, 0);
                                }
                                grp_walk = grp_walk->next;
                        }
                        /* }}} */
                }
                /* }}} */
        } else if (level == 1) { /* {{{ */
                entr_s = entr_smpl(pkt_head);
                if (shift == 1) {
                        /* gain source is higest {{{ */
                        /* gain {{{ */
                        grp_intr_dst(pkt_head, &grp_dst_head, &grp_dst_tail);
                        grp_intr_proto(pkt_head, &grp_proto_head, &grp_proto_tail);
                        gain_proto = entr_s - entr_proto;
                        /* }}} */
                        if (gain_dst > gain_proto) {
                                /* gain destination is higer {{{ */
                                grp_walk = grp_dst_head;
                                while (grp_walk != NULL) {
                                        tmp = pkt_filter(pkt_head, 0, grp_walk->data, 0, 0, 0,
                                                 &l_pkt_head, &l_pkt_tail);
                                        if (tmp == PKT_ALL_NORM) {
                                                /* pruning / ignore */
                                        } else if (tmp == PKT_ALL_INTR) {
                                                ipt_blk(src, grp_walk->data, 0, 0, 0);
                                        } else {
                                                id3(2, l_pkt_head, 3, src, grp_walk->data, 0, 0);
                                        }
                                        grp_walk = grp_walk->next;
                                }
                                /* }}} */
                        } else {
                                /* gain protocol is higer {{{ */
                                grp_walk = grp_proto_head;
                                while (grp_walk != NULL) {
                                        tmp = pkt_filter(pkt_head, 0, 0, grp_walk->data, 0, 0,
                                                  &l_pkt_head, &l_pkt_tail);
                                      if (tmp == PKT_ALL_NORM) {
                                            /* pruning / ignore */
                                      } else if (tmp == PKT_ALL_INTR) {
                                            ipt_blk(src, 0, grp_walk->data, 0, 0);
                                      } else {
                                            id3(2, l_pkt_head, 5, src, 0, grp_walk->data, 0);
                                      }
                                      grp_walk = grp_walk->next;
                                }
                                /* }}} */
                          }
                          /* }}} */
                    } else if (shift == 2) {
                          /* gain destination is higest {{{ */
                          /* gain {{{ */
                          grp_intr_src(pkt_head, &grp_src_head, &grp_src_tail);
                          grp_intr_proto(pkt_head, &grp_proto_head, &grp_proto_tail);
                          entr_src   = entr_attr(grp_src_head);
                          entr_proto = entr_attr(grp_proto_head);
                          gain_src   = entr_s - entr_src;
                          gain_proto = entr_s - entr_proto;
                          /* }}} */
                          if (gain_src > gain_proto) {
                                /* gain source is higer {{{ */
                                grp_walk = grp_src_head;
                                while (grp_walk != NULL) {
                                      tmp = pkt_filter(pkt_head, grp_walk->data, 0, 0, 0, 0,
                                                  &l_pkt_head, &l_pkt_tail);
                                      if (tmp == PKT_ALL_NORM) {
                                            /* pruning / ignore */
                                      } else if (tmp == PKT_ALL_INTR) {
                                            ipt_blk(grp_walk->data, dst, 0, 0, 0);
                                      } else {
                                            id3(2, l_pkt_head, 3, grp_walk->data, dst, 0, 0);
                                      }
                                      grp_walk = grp_walk->next;
                                }
                                /* }}} */
                          } else {
                                /* gain protocol is higer {{{ */
                                grp_walk = grp_proto_head;
                                while (grp_walk != NULL) {
                                      tmp = pkt_filter(pkt_head, 0, 0, grp_walk->data, 0, 0,
                                                  &l_pkt_head, &l_pkt_tail);
                                      if (tmp == PKT_ALL_NORM) {
                                            /* pruning / ignore */
                                      } else if (tmp == PKT_ALL_INTR) {
                                            ipt_blk(0, dst, grp_walk->data, 0, 0);
                                      } else {
                                            id3(2, l_pkt_head, 6, 0, dst, grp_walk->data, 0);
                                      }
                                      grp_walk = grp_walk->next;
                                }
                                /* }}} */
                          }
                          /* }}} */
                    } else {
                          /* gain proto is higest {{{ */
                          /* gain {{{ */
                          grp_intr_src(pkt_head, &grp_src_head, &grp_src_tail);
                          grp_intr_dst(pkt_head, &grp_dst_head, &grp_dst_tail);
                          entr_src = entr_attr(grp_src_head);
                          entr_dst = entr_attr(grp_dst_head);
                          gain_src = entr_s - entr_src;
```

```
        gain_dst = entr_s - entr_dst;
        /* }}} */
        if (gain_src > gain_dst) {
            /* gain source is higer {{{ */
            grp_walk = grp_src_head;
            while (grp_walk != NULL) {
                tmp = pkt_filter(pkt_head, grp_walk->data, 0, 0, 0, 0,
                           &l_pkt_head, &l_pkt_tail);
                if (tmp == PKT_ALL_NORM) {
                    /* pruning / ignore */
                } else if (tmp == PKT_ALL_INTR) {
                    ipt_blk(grp_walk->data, 0, proto, 0, 0);
                } else {
                    id3(2, l_pkt_head, 5, grp_walk->data, 0, proto, 0);
                }
                grp_walk = grp_walk->next;
            }
            /* }}} */
        } else {
            /* gain destination is higer {{{ */
            grp_walk = grp_dst_head;
            while (grp_walk != NULL) {
                tmp = pkt_filter(pkt_head, 0, grp_walk->data, 0, 0, 0,
                           &l_pkt_head, &l_pkt_tail);
                if (tmp == PKT_ALL_NORM) {
                    /* pruning / ignore */
                } else if (tmp == PKT_ALL_INTR) {
                    ipt_blk(0, grp_walk->data, proto, 0, 0);
                } else {
                    id3(2, l_pkt_head, 3, 0, grp_walk->data, proto, 0);
                }
                grp_walk = grp_walk->next;
            }
            /* }}} */
        }
        /* }}} */
    }
    /* }}} */
} else if (level == 2) { /* {{{ */
    if (shift == 3) {
        grp_intr_proto(pkt_head, &grp_proto_head, &grp_proto_tail);
        grp_walk = grp_proto_head;
        while (grp_walk != NULL) {
            tmp = pkt_filter(pkt_head, 0, 0, grp_walk->data, 0, 0,
                       &l_pkt_head, &l_pkt_tail);
            if (tmp == PKT_ALL_NORM) {
                /* pruning / ignore */
            } else if (tmp == PKT_ALL_INTR) {
                ipt_blk(src, dst, grp_walk->data, 0, 0);
            } else {
                id3(3, l_pkt_head, 0, src, dst, grp_walk->data, 0);
            }
            grp_walk = grp_walk->next;
        }
    } else if (shift == 5) {
        grp_intr_dst(pkt_head, &grp_dst_head, &grp_dst_tail);
        grp_walk = grp_dst_head;
        while (grp_walk != NULL) {
            tmp = pkt_filter(pkt_head, 0, grp_walk->data, 0, 0, 0,
                       &l_pkt_head, &l_pkt_tail);
            if (tmp == PKT_ALL_NORM) {
                /* pruning / ignore */
            } else if (tmp == PKT_ALL_INTR) {
                ipt_blk(src, grp_walk->data, proto, 0, 0);
            } else {
```

```
                                        id3(3, l_pkt_head, 0, src, grp_walk->data, proto, 0);
                                }
                                grp_walk = grp_walk->next;
                        }
                } else if (shift == 6) {
                        grp_intr_src(pkt_head, &grp_src_head, &grp_src_tail);
                        grp_walk = grp_src_head;
                        while (grp_walk != NULL) {
                                tmp = pkt_filter(pkt_head, grp_walk->data, 0, 0, 0, 0,
                                          &l_pkt_head, &l_pkt_tail);
                                if (tmp == PKT_ALL_NORM) {
                                        /* pruning / ignore */
                                } else if (tmp == PKT_ALL_INTR) {
                                        ipt_blk(grp_walk->data, dst, proto, 0, 0);
                                } else {
                                        id3(3, l_pkt_head, 0, grp_walk->data, dst, proto, 0);
                                }
                                grp_walk = grp_walk->next;
                        }
                }
                /* }}} */
        } else if (level == 3) { /* {{{ */
                grp_intr_dport(pkt_head, &grp_cmpl_head, &grp_cmpl_tail);
                grp_walk = grp_cmpl_head;
                        while (grp_walk != NULL) {
                                tmp = pkt_filter(pkt_head, 0, 0, 0, 0, grp_walk->data,
                                          &l_pkt_head, &l_pkt_tail);
                                if (tmp == PKT_ALL_NORM) {
                                        /* pruning / ignore */
                                } else if (tmp == PKT_ALL_INTR) {
                                        ipt_blk(src, dst, proto, 0, grp_walk->data);
                                } else {
                                        id3(4, l_pkt_head, 0, src, dst, proto, grp_walk->data);
                                }
                                grp_walk = grp_walk->next;
                        }
                /* }}} */
        } else if (level == 4) { /* {{{ */
                grp_intr_sport(pkt_head, &grp_cmpl_head, &grp_cmpl_tail);
                grp_walk = grp_cmpl_head;
                        while (grp_walk != NULL) {
                                tmp = pkt_filter(pkt_head, 0, 0, 0, grp_walk->data, 0,
                                          &l_pkt_head, &l_pkt_tail);
                                if (tmp == PKT_ALL_NORM) {
                                        /* pruning / ignore */
                                } else if (tmp == PKT_ALL_INTR) {
                                        ipt_blk(src, dst, proto, grp_walk->data, dport);
                                }
                                grp_walk = grp_walk->next;
                        }
                /* }}} */
        }
        /* freeing {{{ */
        lst_pkt_free(l_pkt_head);
        lst_grp_intr_free(grp_src_head);
        lst_grp_intr_free(grp_cmpl_head);
        /* }}} */
}
/* }}} */
/* id3_sdpd() {{{ */
void id3_sdpd(char level, struct lst_pkt_t *pkt_head, char shift,
        unsigned int src, unsigned int dst, unsigned int proto,
        unsigned int dport)
{
        /* vars {{{ */
```

```
struct lst_grp_intr_t *grp_src_head = NULL,
                                        *grp_src_tail,
                                        *grp_dst_head = NULL,
                                        *grp_dst_tail,
                                        *grp_cmpl_head = NULL,
                                        *grp_cmpl_tail,
                                        *grp_walk;
struct lst_grp_intr2_t *grp_proto_dport_head = NULL,
                                        *grp_proto_dport_tail,
                                        *grp_walk2;
struct lst_pkt_t *l_pkt_head = NULL,
                               *l_pkt_tail;
float entr_s,
        entr_src,
        entr_dst,
        entr_proto_dport,
        gain_src,
        gain_dst,
        gain_proto_dport;
char  tmp;
/* }}} */
if (level == 0) { /* {{{ */
        /* grouping {{{ */
        grp_intr_src(pkt_head, &grp_src_head, &grp_src_tail);
        grp_intr_dst(pkt_head, &grp_dst_head, &grp_dst_tail);
        grp_intr_proto_dport(pkt_head, &grp_proto_dport_head,
                    &grp_proto_dport_tail);
        /* }}} */
        /* calculate entropy and gain {{{ */
        entr_s          = entr_smpl(pkt_head);
        entr_src        = entr_attr(grp_src_head);
        entr_dst        = entr_attr(grp_dst_head);
        entr_proto_dport = entr_attr2(grp_proto_dport_head);
        gain_src        = entr_s - entr_src;
        gain_dst        = entr_s - entr_dst;
        gain_proto_dport = entr_s - entr_proto_dport;
        /* }}} */
        if ((gain_src > gain_dst) && (gain_src > gain_proto_dport)) {
                /* gain source is higest {{{ */
                grp_walk = grp_src_head;
                while (grp_walk != NULL) {
                        tmp = pkt_filter(pkt_head, grp_walk->data, 0, 0, 0, 0,
                                &l_pkt_head, &l_pkt_tail);
                        if (tmp == PKT_ALL_NORM) {
                                /* pruning / ignore */
                        } else if (tmp == PKT_ALL_INTR) {
                                ipt_blk(grp_walk->data, 0, 0, 0, 0);
                        } else {
                                id3_sdpd(1, l_pkt_head, 1, grp_walk->data, 0, 0, 0);
                        }
                        grp_walk = grp_walk->next;
                }
                /* }}} */
        } else if ((gain_dst > gain_src) && (gain_dst > gain_proto_dport)) {
                /* gain destination is higest {{{ */
                grp_walk = grp_dst_head;
                while (grp_walk != NULL) {
                        tmp = pkt_filter(pkt_head, 0, grp_walk->data, 0, 0, 0,
                                &l_pkt_head, &l_pkt_tail);
                        if (tmp == PKT_ALL_NORM) {
                                /* pruning / ignore */
                        } else if (tmp == PKT_ALL_INTR) {
                                ipt_blk(0, grp_walk->data, 0, 0, 0);
                        } else {
                                id3_sdpd(1, l_pkt_head, 2, 0, grp_walk->data, 0, 0);
                }
                grp_walk = grp_walk->next;
            }
            /* }}} */
        } else {
            /* gain protocol and dport is higest {{{ */
            grp_walk2 = grp_proto_dport_head;
            while (grp_walk2 != NULL) {
                tmp = pkt_filter(pkt_head, 0, 0, grp_walk2->data, 0,
                      grp_walk2->datb, &l_pkt_head, &l_pkt_tail);
                if (tmp == PKT_ALL_NORM) {
                    /* pruning / ignore */
                } else if (tmp == PKT_ALL_INTR) {
                    ipt_blk(0, 0, grp_walk2->data, 0, grp_walk2->datb);
                } else {
                    id3_sdpd(1, l_pkt_head, 12, 0, 0, grp_walk2->data,
                          grp_walk2->datb);
                }
                grp_walk2 = grp_walk2->next;
            }
            /* }}} */
        }
        /* }}} */
    } else if (level == 1) { /* {{{ */
        entr_s = entr_smpl(pkt_head);
        if (shift == 1) {
            /* gain source is higest {{{ */
            /* gain {{{ */
            grp_intr_dst(pkt_head, &grp_dst_head, &grp_dst_tail);
            grp_intr_proto_dport(pkt_head, &grp_proto_dport_head,
                  &grp_proto_dport_tail);
            entr_dst        = entr_attr(grp_dst_head);
            entr_proto_dport = entr_attr2(grp_proto_dport_head);
            gain_dst        = entr_s - entr_dst;
            gain_proto_dport = entr_s - entr_proto_dport;
            /* }}} */
            if (gain_dst > gain_proto_dport) {
                /* gain destination is higer {{{ */
                grp_walk = grp_dst_head;
                while (grp_walk != NULL) {
                    tmp = pkt_filter(pkt_head, 0, grp_walk->data, 0, 0, 0,
                          &l_pkt_head, &l_pkt_tail);
                    if (tmp == PKT_ALL_NORM) {
                        /* pruning / ignore */
                    } else if (tmp == PKT_ALL_INTR) {
                        ipt_blk(src, grp_walk->data, 0, 0, 0);
                    } else {
                        id3_sdpd(2, l_pkt_head, 3, src, grp_walk->data, 0,
0);

                    }
                    grp_walk = grp_walk->next;
                }
                /* }}} */
            } else {
                /* gain protocol and dport is higer {{{ */
                grp_walk2 = grp_proto_dport_head;
                while (grp_walk2 != NULL) {
                    tmp = pkt_filter(pkt_head, 0, 0, grp_walk2->data, 0,
                          grp_walk2->datb, &l_pkt_head, &l_pkt_tail);
                    if (tmp == PKT_ALL_NORM) {
                        /* pruning / ignore */
                    } else if (tmp == PKT_ALL_INTR) {
                        ipt_blk(src,   0,   grp_walk2->data,   0,   grp_walk2-
>datb);

                    } else {
```

```
                                        id3_sdpd(2,  l_pkt_head,  13,  src,  0,  grp_walk2-
>data,
                                            grp_walk2->datb);
                                }
                                grp_walk2 = grp_walk2->next;
                        }
                        /* }}} */
                }
                /* }}} */
        } else if (shift == 2) {
                /* gain destination is higest {{{ */
                /* gain {{{ */
                grp_intr_src(pkt_head, &grp_src_head, &grp_src_tail);
                grp_intr_proto_dport(pkt_head, &grp_proto_dport_head,
                           &grp_proto_dport_tail);
                entr_src        = entr_attr(grp_src_head);
                entr_proto_dport = entr_attr2(grp_proto_dport_head);
                gain_src        = entr_s - entr_src;
                gain_proto_dport = entr_s - entr_proto_dport;
                /* }}} */
                if (gain_src > gain_proto_dport) {
                        /* gain source is higer {{{ */
                        grp_walk = grp_src_head;
                        while (grp_walk != NULL) {
                                tmp = pkt_filter(pkt_head, grp_walk->data, 0, 0, 0, 0,
                                         &l_pkt_head, &l_pkt_tail);
                                if (tmp == PKT_ALL_NORM) {
                                        /* pruning / ignore */
                                } else if (tmp == PKT_ALL_INTR) {
                                        ipt_blk(grp_walk->data, dst, 0, 0, 0);
                                } else {
                                        id3_sdpd(2,  l_pkt_head,  3,  grp_walk->data,  dst,  0,
0);

                                }
                                grp_walk = grp_walk->next;
                        }
                        /* }}} */
                } else {
                        /* gain protocol and dport is higer {{{ */
                        grp_walk2 = grp_proto_dport_head;
                        while (grp_walk != NULL) {
                                tmp = pkt_filter(pkt_head, 0, 0, grp_walk2->data, 0,
                                         grp_walk2->datb, &l_pkt_head, &l_pkt_tail);
                                if (tmp == PKT_ALL_NORM) {
                                        /* pruning / ignore */
                                } else if (tmp == PKT_ALL_INTR) {
                                        ipt_blk(0,   dst,   grp_walk2->data,   0,   grp_walk2-
>datb);
                                } else {
                                        id3_sdpd(2,  l_pkt_head,  14,  0,  dst,  grp_walk2-
>data,
                                            grp_walk2->datb);
                                }
                                grp_walk = grp_walk->next;
                        }
                        /* }}} */
                }
                /* }}} */
        } else {
                /* gain protocol and dport is higest {{{ */
                /* gain {{{ */
                grp_intr_src(pkt_head, &grp_src_head, &grp_src_tail);
                grp_intr_dst(pkt_head, &grp_dst_head, &grp_dst_tail);
                entr_src = entr_attr(grp_src_head);
                entr_dst = entr_attr(grp_dst_head);
```

```
                        gain_src = entr_s - entr_src;
                        gain_dst = entr_s - entr_dst;
                        /* }}} */
                        if (gain_src > gain_dst) {
                                /* gain source is higer {{{ */
                                grp_walk = grp_src_head;
                                while (grp_walk != NULL) {
                                        tmp = pkt_filter(pkt_head, grp_walk->data, 0, 0, 0, 0,
                                                   &l_pkt_head, &l_pkt_tail);
                                        if (tmp == PKT_ALL_NORM) {
                                                /* pruning / ignore */
                                        } else if (tmp == PKT_ALL_INTR) {
                                                ipt_blk(grp_walk->data, 0, proto, 0, dport);
                                        } else {
                                                id3_sdpd(2,   l_pkt_head,   13,   grp_walk->data,   0,
proto,
                                                      dport);
                                        }
                                        grp_walk = grp_walk->next;
                                }
                                /* }}} */
                        } else {
                                /* gain destination is higer {{{ */
                                grp_walk = grp_dst_head;
                                while (grp_walk != NULL) {
                                        tmp = pkt_filter(pkt_head, 0, grp_walk->data, 0, 0, 0,
                                                   &l_pkt_head, &l_pkt_tail);
                                        if (tmp == PKT_ALL_NORM) {
                                                /* pruning / ignore */
                                        } else if (tmp == PKT_ALL_INTR) {
                                                ipt_blk(0, grp_walk->data, proto, 0, dport);
                                        } else {
                                                id3_sdpd(2,   l_pkt_head,   14,   0,   grp_walk->data,
proto,
                                                      dport);
                                        }
                                        grp_walk = grp_walk->next;
                                }
                                /* }}} */
                        }
                        /* }}} */
                }
                /* }}} */
        } else if (level == 2) { /* {{{ */
                if (shift == 3) {
                        grp_intr_proto_dport(pkt_head, &grp_proto_dport_head,
                                   &grp_proto_dport_tail);
                        grp_walk2 = grp_proto_dport_head;
                        while (grp_walk2 != NULL) {
                                tmp = pkt_filter(pkt_head, 0, 0, grp_walk2->data, 0,
                                           grp_walk2->datb, &l_pkt_head, &l_pkt_tail);
                                if (tmp == PKT_ALL_NORM) {
                                        /* pruning / ignore */
                                } else if (tmp == PKT_ALL_INTR) {
                                        ipt_blk(src, dst, grp_walk2->data, 0, grp_walk2->datb);
                                } else {
                                        id3_sdpd(3, l_pkt_head, 0, src, dst, grp_walk2->data,
                                              grp_walk2->datb);
                                }
                                grp_walk2 = grp_walk2->next;
                        }
                } else if (shift == 13) {
                        grp_intr_dst(pkt_head, &grp_dst_head, &grp_dst_tail);
                        grp_walk = grp_dst_head;
                        while (grp_walk != NULL) {
```

```
                                        tmp = pkt_filter(pkt_head, 0, grp_walk->data, 0, 0, 0,
                                                &l_pkt_head, &l_pkt_tail);
                                        if (tmp == PKT_ALL_NORM) {
                                                /* pruning / ignore */
                                        } else if (tmp == PKT_ALL_INTR) {
                                                ipt_blk(src, grp_walk->data, proto, 0, dport);
                                        } else {
                                                id3_sdpd(3, l_pkt_head, 0, src, grp_walk->data, proto,
                                                        dport);
                                        }
                                        grp_walk = grp_walk->next;
                                }
                        } else {
                                grp_intr_src(pkt_head, &grp_src_head, &grp_src_tail);
                                grp_walk = grp_src_head;
                                while (grp_walk != NULL) {
                                        tmp = pkt_filter(pkt_head, grp_walk->data, 0, 0, 0, 0,
                                                &l_pkt_head, &l_pkt_tail);
                                        if (tmp == PKT_ALL_NORM) {
                                                /* pruning / ignore */
                                        } else if (tmp == PKT_ALL_INTR) {
                                                ipt_blk(grp_walk->data, dst, proto, 0, dport);
                                        } else {
                                                id3_sdpd(3, l_pkt_head, 0, grp_walk->data, dst, proto,
                                                        dport);
                                        }
                                        grp_walk = grp_walk->next;
                                }
                        }
                        /* }}} */
                } else if (level == 3) { /* {{{ */
                        grp_intr_sport(pkt_head, &grp_cmpl_head, &grp_cmpl_tail);
                        grp_walk = grp_cmpl_head;
                                while (grp_walk != NULL) {
                                        tmp = pkt_filter(pkt_head, 0, 0, 0, grp_walk->data, 0,
                                                &l_pkt_head, &l_pkt_tail);
                                        if (tmp == PKT_ALL_NORM) {
                                                /* pruning / ignore */
                                        } else if (tmp == PKT_ALL_INTR) {
                                                ipt_blk(src, dst, proto, grp_walk->data, dport);
                                        }
                                        grp_walk = grp_walk->next;
                                }
                        /* }}} */
                }
                /* freeing {{{ */
                lst_pkt_free(l_pkt_head);
                lst_grp_intr_free(grp_src_head);
                lst_grp_intr_free(grp_dst_head);
                lst_grp_intr2_free(grp_proto_dport_head);
                lst_grp_intr_free(grp_cmpl_head);
                /* }}} */
}
/* }}} */

/* vim:ts=4:sw=4:tw=80:fdm=marker:cin:
 */
```

ipt.c

```
#include <stdio.h>
#include <netdb.h>
#include <string.h>
#include <stdlib.h>
#include <unistd.h>
#include <arpa/inet.h>
#include <sys/types.h>
#include <sys/wait.h>

/* ipt_blk() {{{ */
void ipt_blk(unsigned int src, unsigned int dst, unsigned int proto,
        unsigned int sport, unsigned int dport)
{
        struct protoent *protoe;
        char saddr[INET_ADDRSTRLEN];
        char *env[] = {NULL};
        char **argv;
        char *arg;
        char buff[11];
        int idx;
        struct in_addr iaddr;
        pid_t pid;

        argv = (char **) malloc(16 * sizeof(char *));
        arg = strdup("iptables");
        argv[0] = arg;
        arg = strdup("-A");
        argv[1] = arg;
        arg = strdup("FORWARD");
        argv[2] = arg;
        idx = 2;


        if (src) {
                iaddr.s_addr = src;
                inet_ntop(AF_INET, &iaddr, saddr, INET_ADDRSTRLEN);
                idx++;
                arg = strdup("-s");
                argv[idx] = arg;
                idx++;
                arg = strdup(saddr);
                argv[idx] = arg;
        }
        if (dst) {
                iaddr.s_addr = dst;
                inet_ntop(AF_INET, &iaddr, saddr, INET_ADDRSTRLEN);
                idx++;
                arg = strdup("-d");
                argv[idx] = arg;
                idx++;
                arg = strdup(saddr);
                argv[idx] = arg;
        }
        if (proto) {
                protoe = getprotobynumber(proto);
                idx++;
                arg = strdup("-p");
                argv[idx] = arg;
                idx++;
                arg = strdup(protoe->p_name);
                argv[idx] = arg;
                if (sport) {
```

```
					idx++;
					arg = strdup("--sport");
					argv[idx] = arg;
					idx++;
					sprintf(buff, "%d", sport);
					arg = strdup(buff);
					argv[idx] = arg;
				}
				if (dport) {
					idx++;
					arg = strdup("--dport");
					argv[idx] = arg;
					idx++;
					sprintf(buff, "%d", dport);
					arg = strdup(buff);
					argv[idx] = arg;
				}
			}
			idx++;
			arg = strdup("-j");
			argv[idx] = arg;
			idx++;
			arg = strdup("DROP");
			argv[idx] = arg;
			idx++;
			argv[idx] = NULL;
			pid = fork();
			if (pid == 0) {
				/* child */
				execve("/usr/sbin/iptables", argv, env);
				exit(EXIT_FAILURE);
			} else if (pid > 0) {
				/* parent */
				wait(NULL);
			}
			for (idx = 0; idx < 16; idx++) {
				if (argv[idx] == NULL) {
					break;
				}
				free(argv[idx]);
			}
			free(argv);
}
/* }}} */
/* ipt_reset() {{{ */
void ipt_reset()
{
			char *argv[] = {"iptables", "-F", "FORWARD", NULL};
			char *env[] = {NULL};
			pid_t pid;

			pid = fork();
			if (pid == 0) {
				/* child */
				execve("/usr/sbin/iptables", argv, env);
				exit(EXIT_FAILURE);
			} else if (pid > 0) {
				/* parent */
				wait(NULL);
			}
}
/* }}} */
/* vim:ts=4:sw=4:tw=80:fdm=marker:cin:
 */
```

lst.h

```
#ifndef _LST_H
#define _LST_H

struct lst_grp_intr_t {
		unsigned int data, yes, no;
		struct lst_grp_intr_t *next;
};

struct lst_grp_intr2_t {
		unsigned int data, datb, yes, no;
		struct lst_grp_intr2_t *next;
};

struct lst_pkt_t {
		unsigned int src, dst, proto, sport, dport, intrusion;
		struct lst_pkt_t *next;
};

void lst_grp_intr_init(struct lst_grp_intr_t **, struct lst_grp_intr_t **);
void lst_grp_intr_add(struct lst_grp_intr_t **, struct lst_grp_intr_t **,
			unsigned int, unsigned int, unsigned int);
void lst_grp_intr_view(struct lst_grp_intr_t *);
struct lst_grp_intr_t *lst_grp_intr_find(struct lst_grp_intr_t *, unsigned int);
void lst_grp_intr_free(struct lst_grp_intr_t *);

void lst_grp_intr2_init(struct lst_grp_intr2_t **, struct lst_grp_intr2_t **);
void lst_grp_intr2_add(struct lst_grp_intr2_t **, struct lst_grp_intr2_t **,
			unsigned int, unsigned int, unsigned int, unsigned int);
void lst_grp_intr2_view(struct lst_grp_intr2_t *);
struct lst_grp_intr2_t *lst_grp_intr2_find(struct lst_grp_intr2_t *,
					unsigned int, unsigned int);
void lst_grp_intr2_free(struct lst_grp_intr2_t *);

void lst_pkt_init(struct lst_pkt_t **, struct lst_pkt_t **);
void lst_pkt_add(struct lst_pkt_t **, struct lst_pkt_t **, unsigned int,
		unsigned int, unsigned int, unsigned int, unsigned int,
					unsigned int);
void lst_pkt_view(struct lst_pkt_t *);
void lst_pkt_free(struct lst_pkt_t *);

#endif /* _LST_H */

/* vim:ts=4:sw=4:tw=80:fdm=marker:cin:
 */
```

lst.c

```
#include <stdio.h>
#include <stdlib.h>
#include <netdb.h>
#include <arpa/inet.h>
#include "lst.h"

/* lst_grp_intr_init() {{{ */
void lst_grp_intr_init(struct lst_grp_intr_t **head, struct lst_grp_intr_t **tail)
{
        *head = *tail = NULL;
}
/* }}} */
/* lst_grp_intr_add() {{{ */
void lst_grp_intr_add(struct lst_grp_intr_t **head, struct lst_grp_intr_t **tail,
    unsigned int data, unsigned int yes, unsigned int no)
{
        struct lst_grp_intr_t *tmp;

        tmp = (struct lst_grp_intr_t *) malloc(sizeof(struct lst_grp_intr_t));
        tmp->data = data;
        tmp->yes  = yes;
        tmp->no   = no;
        if (*head == NULL) {
                *head = *tail = tmp;
        } else {
                (*tail)->next = tmp;
                *tail = (*tail)->next;
        }
        tmp->next = NULL;
}
/* }}} */
/* lst_grp_intr_view() {{{ */
void lst_grp_intr_view(struct lst_grp_intr_t *head)
{
        struct lst_grp_intr_t *walk;

        walk = head;
        while (walk != NULL) {
                printf("%d:%d:%d:%d\n", walk->data, walk->yes, walk->no,
                                walk->yes + walk->no);
                walk = walk->next;
        }
}
/* }}} */
/* lst_grp_intr_find() {{{ */
struct lst_grp_intr_t *lst_grp_intr_find(struct lst_grp_intr_t *head,
                        unsigned int search)
{
        struct lst_grp_intr_t *walk;

        walk = head;
        while ((walk != NULL) && (walk->data != search)) {
                walk = walk->next;
        }
        return walk;
}
/* }}} */
/* lst_grp_intr_free() {{{ */
void lst_grp_intr_free(struct lst_grp_intr_t *head)
{
        struct lst_grp_intr_t *walk;
        walk = head;
```

```
		while (walk != NULL) {
			head = head->next;
			free(walk);
			walk = head;
		}
}
/* }}} */
/* lst_grp_intr2_init() {{{ */
void lst_grp_intr2_init(struct lst_grp_intr2_t **head,
			struct lst_grp_intr2_t **tail)
{
		*head = *tail = NULL;
}
/* }}} */
/* lst_grp_intr2_add() {{{ */
void lst_grp_intr2_add(struct lst_grp_intr2_t **head,
			struct lst_grp_intr2_t **tail,
			unsigned int data, unsigned int datb,
			unsigned int yes, unsigned int no)
{
		struct lst_grp_intr2_t *tmp;

		tmp = (struct lst_grp_intr2_t *) malloc(sizeof(struct lst_grp_intr2_t));
		tmp->data = data;
		tmp->datb = datb;
		tmp->yes  = yes;
		tmp->no   = no;
		if (*head == NULL) {
			*head = *tail = tmp;
		} else {
			(*tail)->next = tmp;
			*tail = (*tail)->next;
		}
		tmp->next = NULL;
}
/* }}} */
/* lst_grp_intr2_view() {{{ */
void lst_grp_intr2_view(struct lst_grp_intr2_t *head)
{
		struct lst_grp_intr2_t *walk;

		walk = head;
		while (walk != NULL) {
			printf("%d:%d:%d:%d:%d\n", walk->data, walk->datb, walk->yes, walk->no,
					walk->yes + walk->no);
			walk = walk->next;
		}
}
/* }}} */
/* lst_grp_intr2_find() {{{ */
struct lst_grp_intr2_t *lst_grp_intr2_find(struct lst_grp_intr2_t *head,
					unsigned int search,
					 unsigned int searci)
{
		struct lst_grp_intr2_t *walk;

		walk = head;
		while ((walk != NULL) &&
		     ((walk->data != search) || (walk->datb != searci))) {
			walk = walk->next;
		}
		return walk;
}
/* }}} */
/* lst_grp_intr2_free() {{{ */
```

```
void lst_grp_intr2_free(struct lst_grp_intr2_t *head)
{
            struct lst_grp_intr2_t *walk;
            walk = head;
            while (walk != NULL) {
                        head = head->next;
                        free(walk);
                        walk = head;
            }
}
/* }}} */
/* lst_pkt_init() {{{ */
void lst_pkt_init(struct lst_pkt_t **head, struct lst_pkt_t **tail)
{
            *head = *tail = NULL;
}
/* }}} */
/* lst_pkt_add() {{{ */
void lst_pkt_add(struct lst_pkt_t **head, struct lst_pkt_t **tail,
              unsigned int src, unsigned int dst, unsigned int proto,
                                    unsigned int sport, unsigned int dport, unsigned int intrusion)
{
            struct lst_pkt_t *tmp;

            tmp = (struct lst_pkt_t *) malloc(sizeof(struct lst_pkt_t));
            tmp->src       = src;
            tmp->dst       = dst;
            tmp->proto     = proto;
            tmp->sport     = sport;
            tmp->dport     = dport;
            tmp->intrusion = intrusion;
            if (*head == NULL) {
                        *head = *tail = tmp;
            } else {
                        (*tail)->next = tmp;
                        *tail = (*tail)->next;
            }
            tmp->next = NULL;
}
/* }}} */
/* lst_pkt_view() {{{ */
void lst_pkt_view(struct lst_pkt_t *head)
{
            struct lst_pkt_t *walk;
            struct protoent *proto;
            struct in_addr src, dst;
            char psrc[INET_ADDRSTRLEN], pdst[INET_ADDRSTRLEN];

            walk = head;
            while (walk != NULL) {
                        proto = getprotobynumber(walk->proto);
                        src.s_addr = walk->src;
                        inet_ntop(AF_INET, &src, psrc, INET_ADDRSTRLEN);
                        dst.s_addr = walk->dst;
                        inet_ntop(AF_INET, &dst, pdst, INET_ADDRSTRLEN);
                        printf("%s|%s:%d->%s:%d%c\n", proto->p_name, psrc, walk->sport, pdst,
                              walk->dport, (walk->intrusion) ? '+' : '-');
                        walk = walk->next;
            }
}
/* }}} */
/* lst_pkt_free() {{{ */
void lst_pkt_free(struct lst_pkt_t *head)
{
            struct lst_pkt_t *walk;
```

```
		walk = head;
		while (walk != NULL) {
			head = head->next;
			free(walk);
			walk = head;
		}
}
/* }}} */
/* vim:ts=4:sw=4:tw=80:fdm=marker:cin:
 */
```

pkt.h

```
#ifndef _PKT_H
#define _PKT_H

#include "lst.h"

#define PKT_NO_MATCH 0 /* no packet match */
#define PKT_ALL_NORM 1 /* all packet(s) is normal (there is no intrusion) */
#define PKT_ALL_INTR 2 /* all packet(s) is intrusion */
#define PKT_NORM_INTR 3
#define PKT_INTR_NORM 3

char pkt_filter(struct lst_pkt_t *, unsigned int, unsigned int, unsigned int,
                unsigned int, unsigned int, struct lst_pkt_t **,
                struct lst_pkt_t **);
#endif /* _PKT_H */
```

pkt.c

```
#include <stdio.h>
#include "pkt.h"
#include "lst.h"

/* pkt_filter() {{{ */
char pkt_filter(struct lst_pkt_t *pkt_head, unsigned int src, unsigned int dst,
          unsigned int proto, unsigned int sport, unsigned int dport,
          struct lst_pkt_t **n_pkt_head, struct lst_pkt_t **n_pkt_tail)
{
        struct lst_pkt_t *pkt_walk;
        int pkt_intr_exists = 0, pkt_norm_exists = 0;

        pkt_walk = pkt_head;
        lst_pkt_init(n_pkt_head, n_pkt_tail);
        while (pkt_walk != NULL) {
                if ((!src   || (src   == pkt_walk->src))   &&
                  (!dst   || (dst   == pkt_walk->dst))   &&
                        (!proto || (proto == pkt_walk->proto)) &&
                        (!sport || (sport == pkt_walk->sport)) &&
                        (!dport || (dport == pkt_walk->dport))) {
                        if (pkt_walk->intrusion == 1) {
                                pkt_intr_exists = 1;
                        } else {
                                pkt_norm_exists = 1;
                        }
                        lst_pkt_add(n_pkt_head, n_pkt_tail, pkt_walk->src, pkt_walk->dst,
                               pkt_walk->proto, pkt_walk->sport, pkt_walk->dport,
                                            pkt_walk->intrusion);
                }
                pkt_walk = pkt_walk->next;
        }

        if (*n_pkt_head == NULL) {
                return PKT_NO_MATCH;
        }

        if (!pkt_intr_exists) {
                return PKT_ALL_NORM;
        } else if (!pkt_norm_exists) {
                return PKT_ALL_INTR;
        }
        return PKT_NORM_INTR;
}
/* }}} */
/* vim:ts=4:sw=4:tw=80:fdm=marker:cin:
 */
```

main.c

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <netdb.h>
#include <arpa/inet.h>
#include <getopt.h>
#include "lst.h"S
#include "grp.h"
#include "id3.h"
#include "pkt.h"
#include "ipt.h"

/* main() {{{ */
int main(int argc, char **argv)
{
        /* vars {{{ */
        FILE *fp;       /* file pointer */
        char buff[256],  /* buffer */
                *p;        /* (help char) pointer */
        struct lst_pkt_t *pkt_head, /* (list) packet head */
                                        *pkt_tail; /* (list) packet tail */
        struct in_addr src, /* source  address */
                                 dst; /* destination address */
        struct protoent *proto; /* protocol */
        unsigned int sport, /* source port */
                                dport, /* destination port */
                                intrusion;
        int opt, opt_idx = 0;
        struct option opt_long[] = {
                {"reset"             , 0, 0, 'r'},
                {"version"           , 0, 0, 'v'},
                {"debug"             , 0, 0, 'd'},
                {"log-packet"        , 1, 0, 'p'},
                {"log-intrusion"     , 1, 0, 'i'},
                {"file-time-reference", 1, 0, 'f'},
                {"algorithm"         , 1, 0, 'a'},
                {"usage"             , 0, 0, 'u'},
                {"help"              , 0, 0, 'h'},
                {"schedule"          , 1, 0, 's'},
                {0                   , 0, 0,  0 }
        };
        int debug = 0, reset, schedule = 0, algo = 0;
        char *file_packet = NULL,
                *file_intr   = NULL,
                *file_ref    = NULL;
        /* }}} */
        /* function prototype {{{ */
        void show_version();
        void show_usage();
        /* }}} */
        /* parse option {{{ */
        while ((opt = getopt_long(argc, argv, "rvVduha:p:i:f:s:", opt_long,
                                &opt_idx)) != -1) {
                switch (opt) {
                        case 'r':
                                reset = 1;
                                break;
                        case 'v':
                        case 'V':
                                show_version();
                                exit(EXIT_SUCCESS);
                        case 'd':
                                debug = 1;
                                break;
                        case 'h':
                        case 'u':
                                show_usage();
                                exit(EXIT_SUCCESS);
                        case 's':
                                schedule = atoi(optarg);
                                break;
                        case 'p':
                                file_packet = strdup(optarg);
                                break;
                        case 'i':
                                file_intr = strdup(optarg);
                                break;
                        case 'f':
                                file_ref = strdup(optarg);
                                break;
                        case 'a':
                                if (strncmp(optarg, "sdpd", 4) == 0) {
                                        algo = 1;
                                } else if (strncmp(optarg, "sdp", 3) == 0) {
                                        algo = 0;
                                } else {
                                        show_usage();
                                        exit(EXIT_SUCCESS);
                                }
                                break;
                }
        }
        /* }}} */
        lst_pkt_init(&pkt_head, &pkt_tail);
        /* read data {{{ */
        fp = fopen("data", "r");
        while (fgets(buff, 255, fp) != NULL) {
                p = strtok(buff, ":"); /* number */
                p = strtok(NULL, ":"); /* src */
                inet_pton(AF_INET, p, &src);
                p = strtok(NULL, ":"); /* dst */
                inet_pton(AF_INET, p, &dst);
                p = strtok(NULL, ":"); /* sport */
                sport = (unsigned int) atoi(p);
                p = strtok(NULL, ":"); /* dport */
                dport = (unsigned int) atoi(p);
                p = strtok(NULL, ":"); /* proto */
                proto = getprotobyname(p);
                p = strtok(NULL, ":"); /* intrusion */
                intrusion =  (strncasecmp(p, "yes", 3) == 0) ?  1 : 0;
                lst_pkt_add(&pkt_head, &pkt_tail, src.s_addr, dst.s_addr,
                        proto->p_proto, sport, dport, intrusion);
        }
        fclose(fp);
        /* }}} */
        ipt_reset();
        if (algo == 0) {
                id3(0, pkt_head, 0, 0, 0, 0, 0);
        } else {
                id3_sdpd(0, pkt_head, 0, 0, 0, 0, 0);
        }
        lst_pkt_free(pkt_head);
        if (file_packet != NULL) free(file_packet);
        if (file_ref    != NULL) free(file_ref);
        if (file_intr   != NULL) free(file_intr);
        return EXIT_SUCCESS;
}
```

```
/* }}} */
/* show_version() {{{ */
void show_version()
{
		printf("NIPS-NID2S3 version 0.1\n");
}
/* }}} */
/* show_usage() {{{ */
void show_usage()
{
		printf("Usage: syh [--algorithm|-a [sdp|sdpd]]\n");
}
/* }}} */
/* vim:ts=4:sw=4:tw=80:fdm=marker:cin:
 */
```