Interested in learning more about security?

SANS Institute InfoSec Reading Room

Challenges of Managing an Intrusion Detection System (IDS) in the Enterprise

Challenges of Managing an Intrusion Detection System (IDS) in the Enterprise

GCIA Gold Certification

Author: Russell Meyer

Adviser: Dominicus Adriyanto Hindarto

Accepted: March 24th 2008

Outline

1. Introduction

While every enterprise is unique, there are common challenges in managing, monitoring and reacting to network IDS alerts. These include: managing the flood of alerts, creating actionable reports, and following-up on the reported alerts. This paper will explore the IDS challenges of a large organization with examples of specific lessons learned in monitoring the internal network.

2. Background

The company referenced in this paper was a large healthcare organization with over 10,000 employees in 40 states and 200+ locations. Most of the servers were centralized but some locations had their own servers. As a healthcare company, the organization had some HIPAA Security Rule projects, including monitoring the IDS for HIPAA compliance (Beaver 2003) (Wilson 2007). The stated task was to implement IDS monitoring and reporting.

The Wide Area Network (WAN) was designed based on the hub and spoke model. Each site (spoke) was connected via a WAN link to the main site (hub), usually the local business office. Each business office was connected to the main data center via another WAN link, usually a T1 or better connection. The main data center was connected to the Internet via two T3 connections serviced by different carriers. The internal network was

separated from the Internet by firewalls but the internal network was not segregated. All traffic going to or coming from the Internet traveled through the main data center.

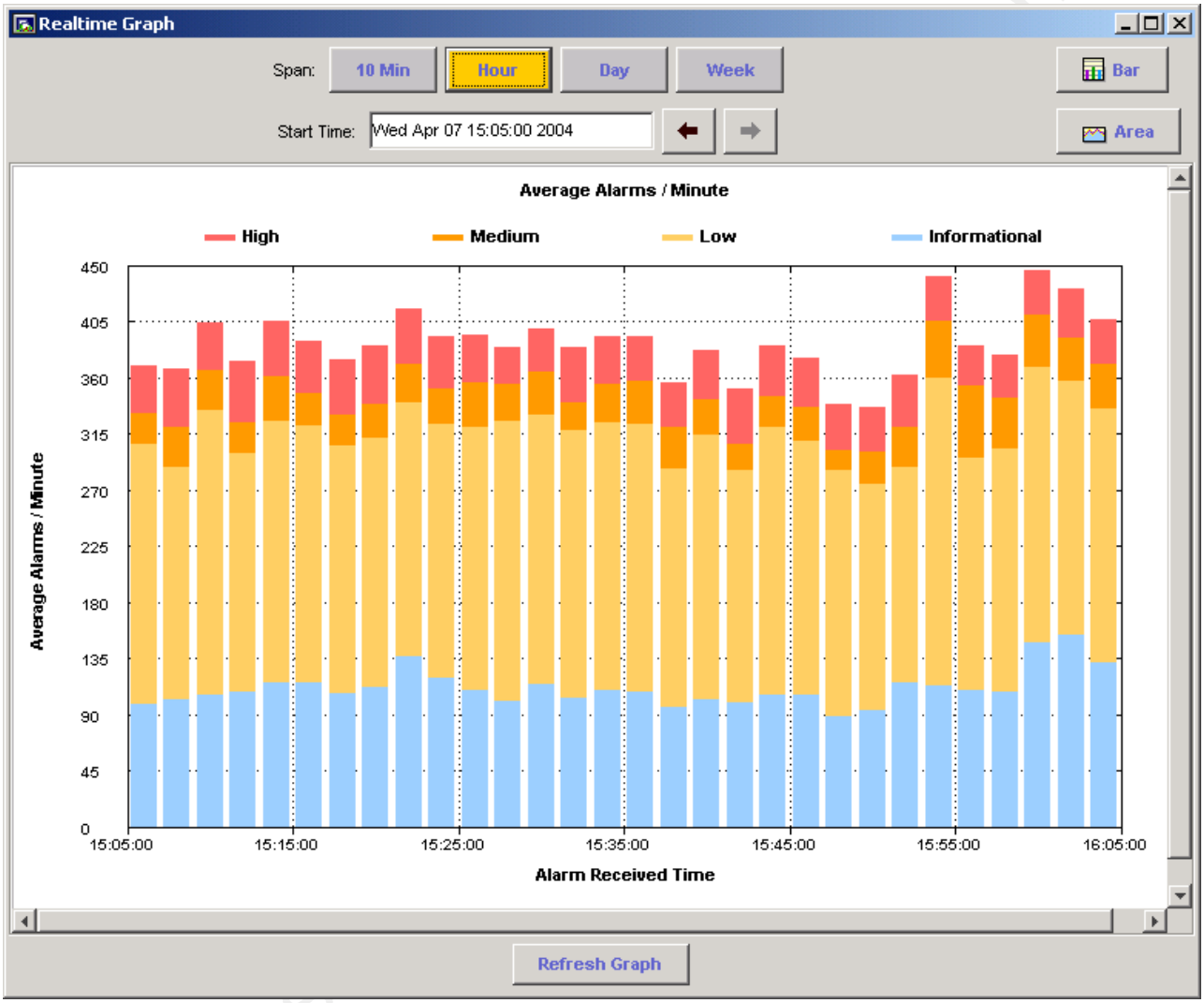
There were about 8000 computers on the network, mostly workstation computers. The organization used mostly Windows 2000 Professional on the desktops and had about 400 NT 4.0 & Windows 2000 servers. There were still some Windows 95 and 98 desktops and a few UNIX and Linux servers. At the time, the organization was running an NT 4.0 domain. Most of the hardware was managed centrally but there were some user-owned laptops and vendor-provided and controlled systems that were used for patient care. These patient care systems were maintained by the vendor as well as the local IT group.

The company had installed Cisco's Intrusion Detection System, one 4210 and one 4250 sensor. These all-in-one appliances were running hardened copies of Red Hat 7.2. Cisco purchased their network based IDS solution, formally known as "NetRanger", from the Wheel group in 1997 (Innella 2001). The 4210 sensor was monitoring traffic in the DMZ while the 4250 was monitoring the internal network traffic passing through the main data center. The organization used Cisco's Java based IDS Event Viewer (IEV) software to monitor their two sensors and record those alerts.

3. Managing the Flood of Alerts

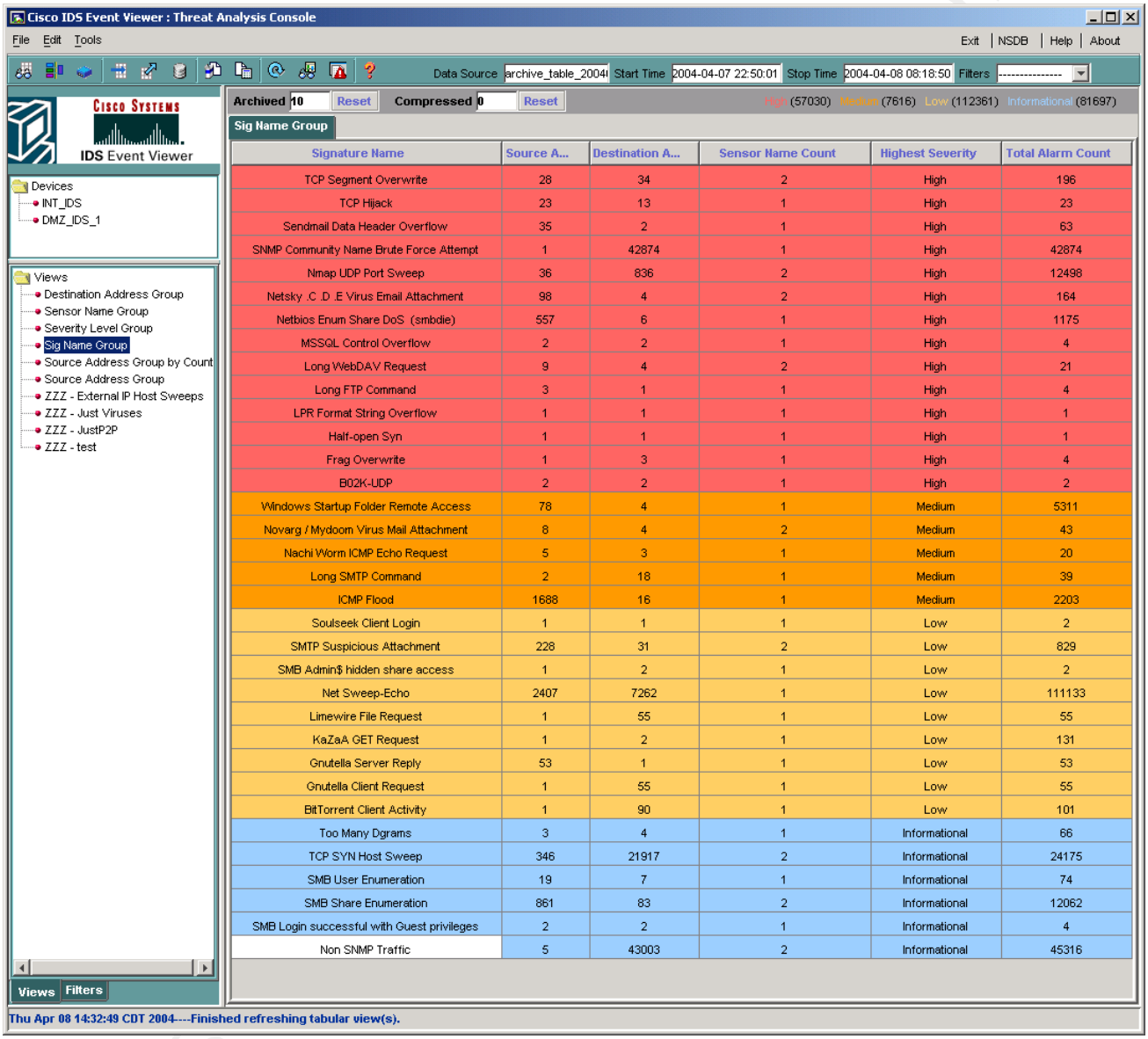
A typical network IDS sensor in the enterprise generates a tremendous number of alerts. There are two major methods for detecting issues: signature detection and anomaly detection. Signature detection will generate an alert whenever traffic matches a known attack pattern while anomaly detection compares current traffic against "normal" traffic and generates an alert on the network. (Newman 2002) An alert does not necessarily mean the sensor found a problem, just that the sensor detected traffic that matched a signature or pattern. These alerts are called false positives and can overwhelm a sensor as well as the staff trying to monitor the sensor.

Alerts per Minute



The above screen shows over 400 alerts a minute on the internal sensor and the sensor averaged 400,000 alerts a day. This number of alerts overwhelmed the response capabilities of the security group. The organization was not able to justify the staff to follow-up on this number of alerts, especially since the probability was that most of the alerts were false positives. (Axelsson 1999)

Alerts by Name



Signature Name	Source A...	Destination A...	Sensor Name Count	Highest Severity	Total Alarm Count
TCP Segment Overwrite	28	34	2	High	196
TCP Hijack	23	13	1	High	23
Sendmail Data Header Overflow	35	2	1	High	63
SNMP Community Name Brute Force Attempt	1	42874	1	High	42874
Nmap UDP Port Sweep	36	836	2	High	12498
Netsky .C .D .E Virus Email Attachment	98	4	2	High	164
Netbios Enum Share DoS (smbdie)	557	6	1	High	1175
MSSQL Control Overflow	2	2	1	High	4
Long WebDAV Request	9	4	2	High	21
Long FTP Command	3	1	1	High	4
LPR Format String Overflow	1	1	1	High	1
Half-open Syn	1	1	1	High	1
Frag Overwrite	1	3	1	High	4
B02K-UDP	2	2	1	High	2
Windows Startup Folder Remote Access	78	4	1	Medium	5311
Novarg / Mydoom Virus Mail Attachment	8	4	2	Medium	43
Nachi Worm ICMP Echo Request	5	3	1	Medium	20
Long SMTP Command	2	18	1	Medium	39
ICMP Flood	1688	16	1	Medium	2203
Soulseek Client Login	1	1	1	Low	2
SMTP Suspicious Attachment	228	31	2	Low	829
SMB Admin$ hidden share access	1	2	1	Low	2
Net Sweep-Echo	2407	7262	1	Low	111133
Limewire File Request	1	55	1	Low	55
KaZaA GET Request	1	2	1	Low	131
Gnutella Server Reply	53	1	1	Low	53
Gnutella Client Request	1	55	1	Low	55
BitTorrent Client Activity	1	90	1	Low	101
Too Many Dgrams	3	4	1	Informational	66
TCP SYN Host Sweep	346	21917	2	Informational	24175
SMB User Enumeration	19	7	1	Informational	74
SMB Share Enumeration	861	83	2	Informational	12062
SMB Login successful with Guest privileges	2	2	1	Informational	4
Non SNMP Traffic	5	43003	2	Informational	45316

The network IDS sensors not only generated thousands of alerts an hour but hundreds of different alerts with different severity levels. In the example above, red was the most severe (highest risk) and blue was informational (lowest risk), according to the Cisco IEV

software. Only a few signatures were generating the majority of the alerts. These alerts were not only in the high risk category but also in the low risk category. All categories needed followed up.

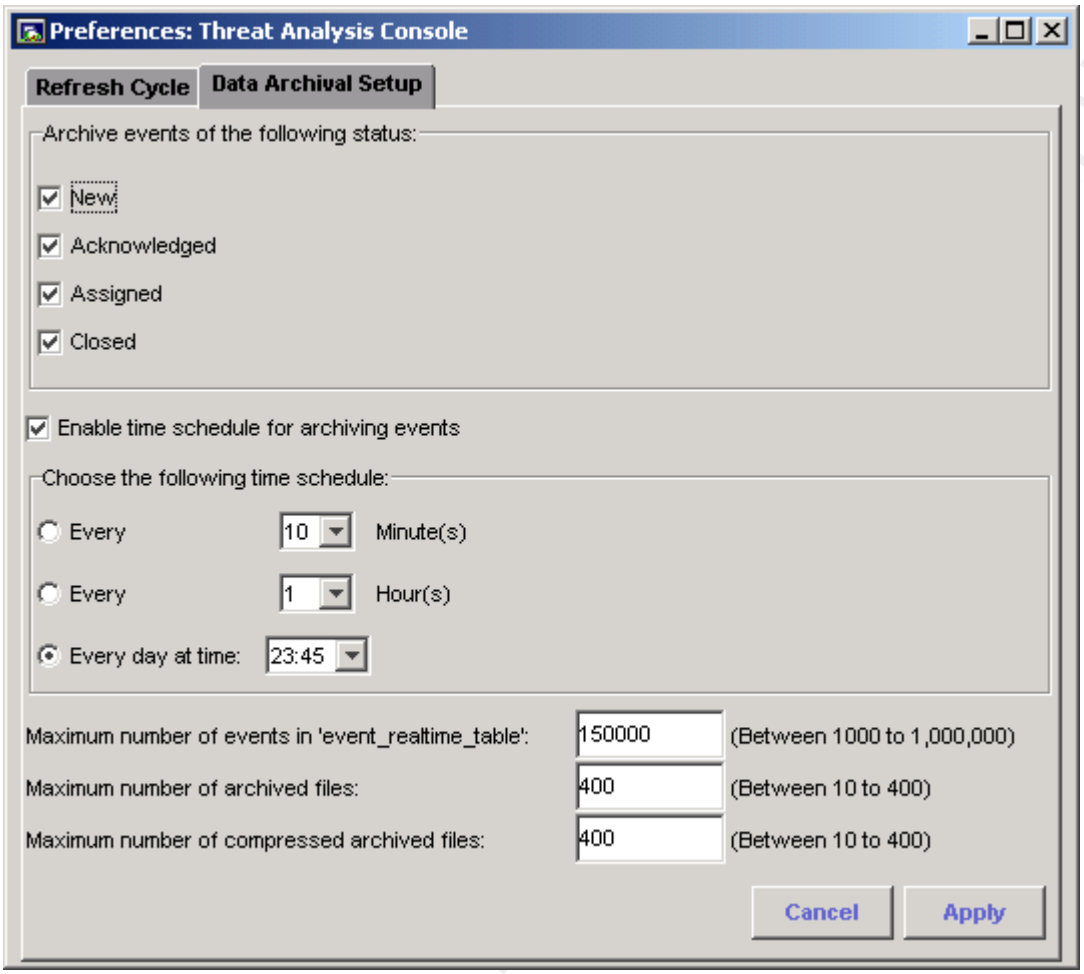
Few organizations have the resources or inclination to correlate and follow-up on all of the alerts generated by the IDS network sensors. The typical commercial IDS sensor comes with a default set of enabled alerts and these enabled alerts can be tuned to filter out obvious false positives. For example, it is usually necessary to tune out the IT management systems that trigger alerts. The IT management system generated alerts would be considered false positives since the traffic generated by these systems is not malicious. One of the issues the organization faces with tuning is "How much to tune out?" If the sensor tunes out too many IP addresses or alerts, the organization risks missing real problems but if the sensor is not sufficiently tuned, the staff will spend needless time chasing false positives. This can lead to a loss of confidence in the capability of IDS to protect the network (Carter, 2002).

In the referenced company, the solution was to record all but the obvious false positives and any additional alerts that the organization had determined worthwhile. A filter was used to weed out all of the alerts except those that needed to be addressed immediately. This way, all of the alert data was captured and recorded for trending and archiving but only the most important alert data was acted upon.

A note about false negatives; false negatives are network traffic that the IDS sensors do not catch, usually because there is no network signature or rule for the event. This organization's IDS approach did not and could not address false negatives since it relied on the IDS sensor to trigger the process to gather more information. If the sensor does not see the event, an alert will never be generated and no additional information will be collected. Just as an alert or two from the sensor does not mean there is an issue, the absence of alerts does not mean there are no issues. An organization should never rely on just one method for detecting problems. In order to make the most out of any organization's IDS, it is important to use up-to-date IDS rules or signatures.

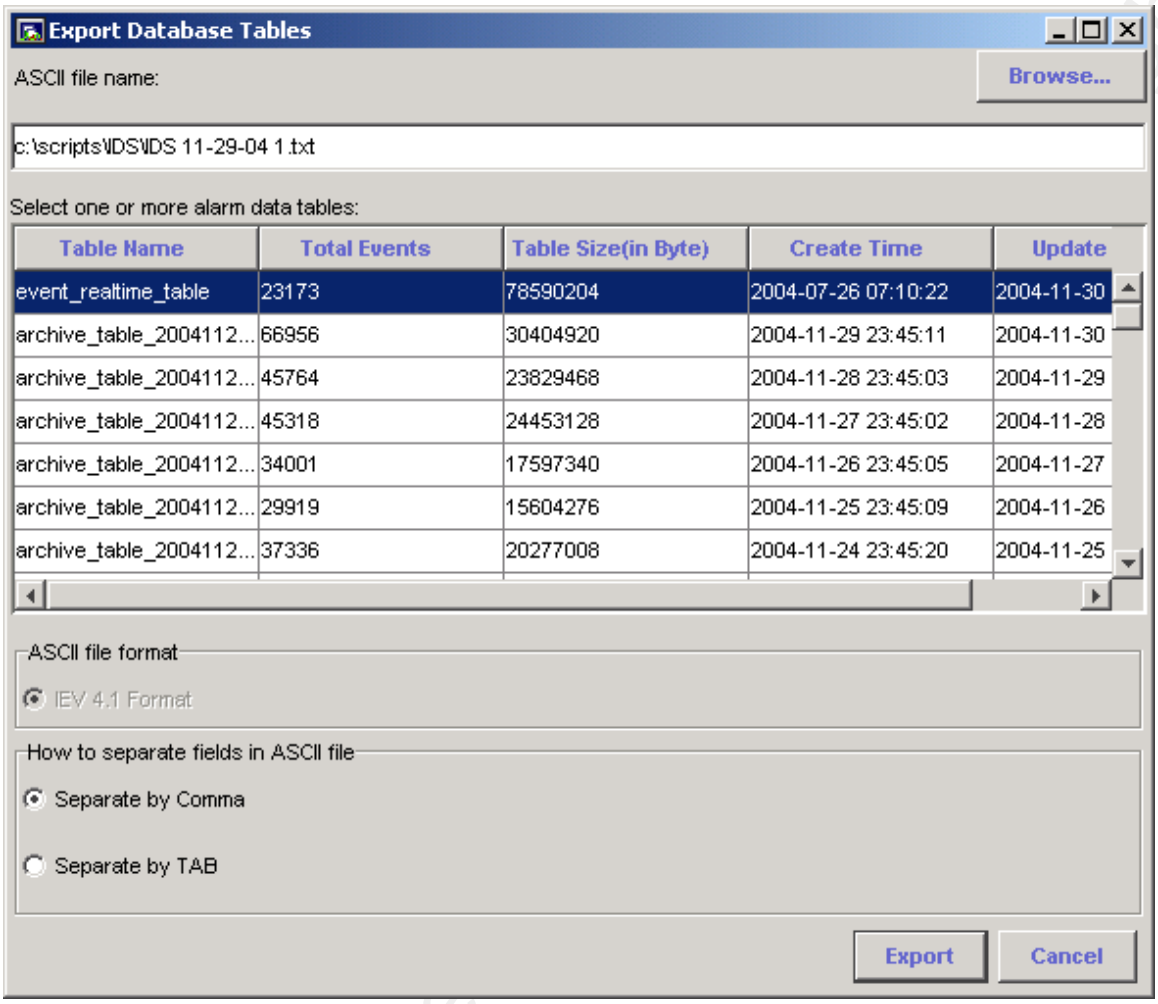
The IEV software included an export function that allowed the export of alert data to a comma delimited (CSV) text file. Using the IEV the IDS sensor data was exported to a text file for additional manipulation.

IEV Configuration



The IEV allowed the user to define how the alert data was archived. The above configuration allowed for 150,000 alerts per file and archived the day at 11:45 each night. 150,000 alerts were usually enough for one day's worth of IDS sensor data.

IEV Alert Export



The export function of the IEV software allowed the alert data to be exported in either common or tab separated format. In the example above, the IDS sensor data for 11-29-04 was exported to a file called “IDS 11-29-04 1.txt” in comma separated format.

Sample Exported Alert.

'5','1078879337720906009','3','INT_IDS','sensorApp','2004-08-31','11:00:29',' 1093946247725656000',
'1093949487725656000','3327','Windows RPC DCOM Overflow','0','\\\\\\x26lt;400 chars>\\','S49','1',
'10.128.7.6','3965','OUT','10.86.26.240','135','OUT','(<10.128.7.6><3965><T1VU>?<10.86.26.240><135><T1VU
>)','2','0','Interval','true','0','0',\N,\N,\N,\N,\N,'Traffic Source: int2 ; Interval Summary: 2 alarms this interval
;','New',\N'5','1078879337720905988','3','INT_IDS','sensorApp','2004-08-31','11:00:14','1093946232394410000'
,'1093949472394410000','3327','Windows RPC DCOM Overflow','0','\\\\\\x26lt;400 chars>\\','S49','1','10.128.7.6'
,'3965','OUT','10.86.26.240','135','OUT','(<10.128.7.6><3965><T1VU>?<10.86.26.240><135><T1VU>)','0',\N,\N,
\N,'0','0','AAAAAMAAAAAAAABGb3GrNJ430hGsDQAQWg0aQgUABgAAsAAAxAIAALaSv8+Rn3zQAAAAANAV
CAABEAgAzMzMzIAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAFihFAAAAAAAYAAAAGAAAABNRU9XBAAA
AMABAAAAAAAAwAAAAAAAAEY7AwAAAAAAAMAAAAAAAABGAAAAADAAAAABAAEAmlvwgMaEQ0uNwY/
GB/9RiQIAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAEAAAABEAgAzMzMzEgAAAAAAAAAAAAAAHC/CwAA
AAAAAAAADjvCwAAAAAAAAAAA8AAAAAAAADwAAAA==$TwBMAE8ARwBZAFwAcwBlAGEAZwBhAHQ
AZQAAABAA//9VAFMATwBOAEMATwBMAE8ARwBZAFwAcwBlAGEAZwBhAHQAZQAAAAkA//9VAFMATwBO
AEMATwBMAE8ARwBZAFwAcwBlAGEAZwBhAHQAZQAAABEA//9VAFMATwBOAEMATwBMAE8ARwBZAFw
AcwBlAGEAZwBhAHQAZQAAABIA//9VAFMATwBOAEMATwBMAE8ARwBZAFwAcwBlAGEAZwBhAHQAZQA
AAAAAAAAAAAAAAAAAAAAAABMTUVNODELADhVCwAAAAAAAAAAAoCAABQYgcAAQAAAAAAAAAA
AAAAAAAA==',\N,\N,\N,\N,'Traffic Source: int2 ;','New',\N

The above represents one exported alert. Cisco documentation provided descriptions of the fields. While there was a lot of information about the alert itself, the alert did not indicate much about the system or system user.

Sample Alert Fields

AlertLevel	Alert Level: 0= informational, 1=low, 2=med, 3=high Alert
SensorName	Name of the sensor, 'INT_IDS' or 'DMZ_IDS_1"
Date	Date of the alert
Time	Time of the alert
AlertID	The Cisco alert ID, i.e. "3030"
AlertName	The Cisco alert name, i.e. "TCP SYN Host Sweep"
SourceIP	The IP address of the system that generated the IDS alert
SourcePort	The port of the system that generated IDS alert
DestIP	The IP address of the destination traffic
DestPort	The port(s) of the destination traffic

After tuning out the biggest generators of false positives, there were still too many alerts and not enough information on the remaining alerts. A decision was made to write a program (Meyer 2008) which would parse the exported IDS alerts, capture the above fields, filter out all but the alerts the organization wanted to pursue and finally capture additional data on the remaining alerts. Cisco Systems also used scripts to help alert their IDS operators to unusually large numbers of IDS alerts (Cisco 2003).

After parsing the data, the Perl program filtered out all of the alerts except those designated for follow-up. This approach to IDS alerts addressed a problem encountered after tuning the IDS sensor. Once the sensor was tuned to eliminate a false positive by IP address or alert, that IP address or alert would never be seen again. That had the potential become a

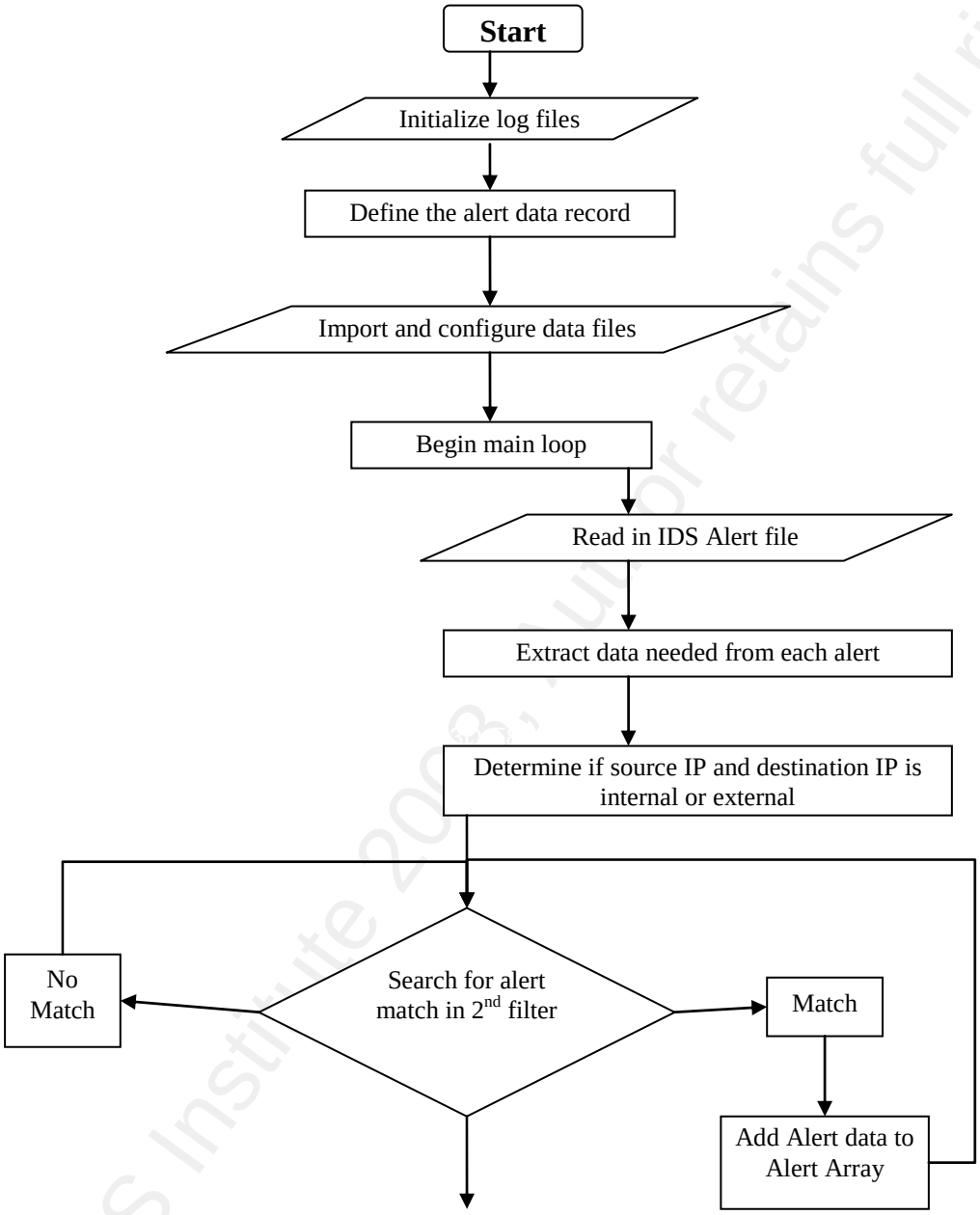
problem. If a system is generating false positives today and the sensor is configured to ignore that IP address or the alert from that IP, the sensor will continue to ignore that IP or IP & alert combination. Even if the IP address is reallocated, the system is taken off line or the alert is updated to eliminate the issue causing the false positive in the first place. After several months, years or IDS engineers, that sensor would become blinded to real threats. By moving most of the filtering process from the sensor to a post-alert process, the sensor can concentrate on capturing and processing as many alerts as possible.

This was a nontraditional approach to dealing with false positives. By using the filter to eliminate most of the alerts and thus most of the false positives the organization could focus on just the alerts it deemed worthy of follow-up. The IDS still generated tens of thousands of alerts each day but the staff concentrated on the clear-cut alerts that could be addressed immediately. These included alerts for known worm traffic, Peer-to-Peer file sharing traffic and spyware & Adware; all of which any security group could make a business case for addressing.

This approach to IDS is not for every enterprise. If the enterprise network is already well run and monitored, the systems on the network are kept patched and there are effective Network Access Control (NAC) measures in place, this approach will not be of great benefit. However, if the internal network is not monitored, the systems on the network are not as

secure or the organization simply does not have the resources to implement a traditional IDS system, this approach could be a starting point. It is also important to remember that the Perl program does not replace the IEV, it supplements it by providing actionable reporting on the alerts the organization has deemed worthy of follow-up.

Flowchart - Filtering



The flowchart illustrates how the program's filter works. From a high level perspective,

the first half of the program does the following:

- Initializes the program
- Processes the configuration and data files
- Begins the main loop and reads the first alert data file
- Extracts and records details of each alert
- Filters out all but the alerts the organization wants to deal with

Once the IDS has been running awhile and the organization has filtered the systems that generated the greatest number of false positives at the sensors, it is time to begin to build the list of alerts and alert criteria for the alerts the organization wants to address. The filter is built using an Excel spreadsheet to document the filter and then exported to a CSV file as input for the program. There are several fields that can be populated:

Filter Details

Field	Description	Example
Action-Filter ID	An internal ID number, starts at 1000	1016
Alert Name	The Cisco NSDB Alert Name	ICMP Network Sweep w/Echo
Alert ID	The Cisco NSDB Alert ID	2100
Alert level	The Cisco IDS Alert level	3 - Low
Category	Broad and simply defined alert categories (spyware, P2P, etc..)	Worm\Virus\Trojan
Action threshold	How many Alerts have to be triggered by IDS before the program reports it. '0' to filter event	10
Action to take	Action to take. Filter, investigate, etc…	Investigate
Source Network	Internal, External or DMZ Internal would be any IP that starts with 10, DMZ = 192, external IP anything else	Internal
Source IP Address	The IP address of the source of the alert, 'any' for any	Any
Source Port	The source TCP or UDP Port number of the alert	Any
Destination Network	Internal, External or DMZ Internal would be any IP that starts with 10, DMZ = 192, external IP anything else	External
Destination IP Address	The IP address of the destination of the alert, 'any' for any	Any
Destination Port	The destination TCP or UDP Port number of the alert	Any
Notes	Filter notes, free text, not used tin the reports. Can be used to document reason for filter	Notes here

In the example above, Cisco alert #2100 “ICMP Network Sweep w/Echo” could be evidence of worm activity or network management activity. Cisco classified the alert as “low” but if the alert is evidence of a worm, the organization would want know about it. The “Action threshold” is set to “10” and the “Destination network” is set to “External”. This means the alert will not be reported unless there are 10 alerts and the destination network is external (i.e.

the Internet). This should eliminate network management activity since the network management tools should not be scanning external network addresses, i.e. the Internet.

In developing the filter list, take into consideration the resources the organization has for IDS alert follow-up. While many of the alerts could justify follow-up from a pure security standpoint, the organization may not be able to justify the resources, at least not in the beginning. It is better to start with clear-cut alerts that are causing the most problems. Care should be taken in determining the criteria to filter an alert. Threshold values need to be determined and justified. It is too easy to just filter an IP address or a range of IP addresses instead of just the false positive alerts they are generating. As time goes on, the filter list should be refined based on alert follow-up feedback in order to produce the most accurate reports.

Once the benefits of following up on the alerts were established, the organization expanded the scope of the alerts to be investigated. Use of the historical data collected pointed out that there were other issues that needed to be addressed. These new alerts were addressed through informal channels at first in order to demonstrate the value of the alerts and to unofficially verify their value for follow-up.

There were no easy solutions to managing the flood of network IDS alerts. The filter approach allowed the sensors to generate the largest number of alerts while filtering out all

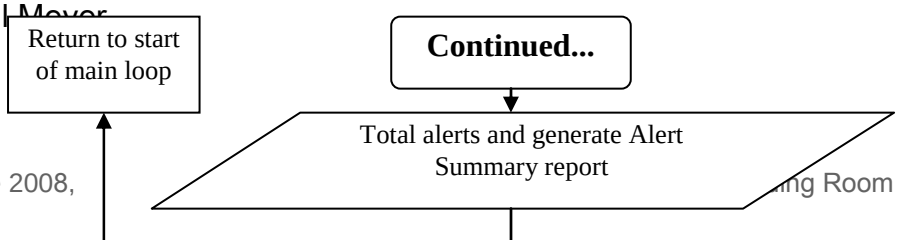
but the alerts the organization chose to address.

4. Creating Actionable Reports for Follow-up

The second challenge that many organizations have is creating an actionable report on the IDS alerts of interest for follow up. The IDS sensors generate little alert data to go on; typically just the name of the alert, IP addresses, ports used and date and time information. In a large organization, just having the IDS alert data is too little information to justify an investigation or follow-up. Additional information is needed.

Once the enterprise has determined the alerts and alert criteria to add to the alert filter, additional information about the systems should be collected to produce a report with enough detail to be actionable. This report should correlate the IDS alert data with network, user and alert source system data to produce a better picture of the event. The report should include enough data that would allow a system owner or IT staff to find the system and help identify the issue.

Flowchart - Reporting



From a high level perspective, the report generating part of the Perl program does the following:

- Summary report data is generated for all of the alerts
- Begin loop for alerts not filtered
- Gather more data about each alert
- Output actionable data details
- End loop for alerts not filtered
- End main loop
- Output summary matrix data
- End program

While follow-up details required will be unique to each organization, the referenced organization gathered the following additional data for each alert that needed follow-up.

Additional Alert Details

Field	Description
Name of the IDS alert	The Cisco name for the IDS alert
IP Address	The host IP address; the host that generated the alert
Host Name	Name of the host, IF it can be resolved (may no longer be on the network)
Source Port	The source port used on the host workstation; where the traffic came from
Destination Port	The port of destination, where the traffic was directed to
Total Alerts	The total number of alerts for this host
Date of Last Alert	Date of the last alert activity
Time of Last Alert	Time of the last alert activity on the host (CST
Category	I defined several categories to help classify the alerts. These included: virus, Spyware, P2P, etc…
Internal or External	It the host targeting an internal (10. and 192.) or external (i.e.Internet) IP address.
User logged into host at time report was run	If available, what user was logged on WHEN the IDS report was run. If the alert is old or the report is rerun with an old exported IEV data file, this information may not be accurate.
NT User Comment Field	The User comment field, from the User's domain account
Date and Time of Last Login	Date and time the user last logged in
MAC Address of Host	The MAC address of the Host
Network Card Manufacture	Company that has registered the MAC address; helpful in tracking down the workstation (for example, if the MAC is registered to Dell, you would look for a
	Dell computer.)
Host OS (based on TTL)	You can usually identify the operating system via the TTL (packet Time-To-Live value)
Site Name	From a lookup table based on the first 3 octets of the IP address. Used to identify the location of the system
Site Contact	The person responsible for the site. This person may or may not be the system owner or custodian but they would know who to contact

Following is an example of an IDS report generated on 2/25/05, focusing on just one host with five alerts.

IDS report

Item	IP Address	Host Name	Source Port	Destination Port	Total Alerts
IRC Channel Join	10.128.9.57	CORP01LT802	1158	6667	1
TCP SYN Host Sweep	10.128.9.57	CORP01LT802	1197	445	130
Windows LSASS RPC Overflow	10.128.9.57	CORP01LT802	1473	445	2
Windows RPC DCOM Overflow	10.128.9.57	CORP01LT802	1181	135	6
Windows SMB/RPC NoOp Sled	10.128.9.57	CORP01LT802	1181	135	8

Date of last alert	Time of last Alert	Category	User logged into host at time report was run	NT User comment field
2/25/2005	13:10:07	Instant Messenger and more	John Smith	101102 Business Office Clerk, Corporate
2/25/2005	13:22:12	Worm\Virus\Trojan	John Smith	101102 Business Office Clerk, Corporate
2/25/2005	13:17:05	Worm\Virus\Trojan	John Smith	101102 Business Office Clerk, Corporate
2/25/2005	13:20:03	Worm\Virus\Trojan	John Smith	101102 Business Office Clerk, Corporate
2/25/2005	13:20:03	Worm\Virus\Trojan	John Smith	101102 Business Office Clerk, Corporate

Date and time of last login	MAC Address of Host	Network Card Manufacture	Host OS (based on TTL)
2/25/2005 12:51	00-D0-59-D9-2A-84	AMBIT MICROSYSTEMS CORP.	NT-2000-XP (126)
2/25/2005 12:51	00-D0-59-D9-2A-84	AMBIT MICROSYSTEMS CORP.	NT-2000-XP (126)
2/25/2005 12:51	00-D0-59-D9-2A-84	AMBIT MICROSYSTEMS CORP.	NT-2000-XP (126)
2/25/2005 12:51	00-D0-59-D9-2A-84	AMBIT MICROSYSTEMS CORP.	NT-2000-XP (126)
2/25/2005 12:51	00-D0-59-D9-2A-84	AMBIT MICROSYSTEMS CORP.	NT-2000-XP (126)

External or Internal	Site name (as identified by first 3 octets of the IP address)	Site Contact
External	Main data Center (VPN)	Robert Smith
External	Main data Center (VPN)	Robert Smith
External	Main data Center (VPN)	Robert Smith
External	Main data Center (VPN)	Robert Smith
External	Main data Center (VPN)	Robert Smith

The above Perl report was generated as a CSV file. The data was reviewed and added to an Excel template formatted using legal size paper in order to include all the alert details on one line. Details of the above example IDS report show how the additional information was generated.

Items - The IDS sensors generated five alerts for this host. The last three alerts were named after well-known Windows vulnerabilities. These alerts were an issue for non-managed or recently re-imaged workstations. If the workstation was not updated before a worm found it, the system had the potential to become infected.

IP Address - The IP address indicated the source of the traffic that generated the alert. Most organizations use Dynamic Host Configuration Protocol (DHCP) to assign workstations' IP addresses, so care must be taken when tracking down systems based on old IDS reports since that IP address could now belong to another system.

Special care should to be taken with VPN assigned IP addresses since the VPN IP

addresses are often recycled and used again. The rapid reuse of IP addresses is found with VPN users and other organizations with sites that have a limited number of IP addresses. In this case, the DHCP lease was three days and the DHCP server usually renewed desktops with the same IP. This meant that users could use the same IP address for months. The IDS report does not prove a workstation is infected, just that a certain IP address triggered an IDS alert at a certain date and time. Further investigation would be needed to determine the problem.

Host Name - In this example, "LT" identified the system as a laptop. A laptop user outside the company was using the VPN (Virtual Private Network) to access the internal company network. CORP001 told us the laptop probably belonged to a user from Corporate, or at the very least, was configured for a user at Corporate. If the IP address was no longer on the network when the report was generated, a lookup table based on IP address and system names was used to determine the hostname. These cases are noted were a "*" after the name.

Source Port – The source ports were usually ports above 1023. This was the case in this example.

Destination Port(s) - The destination port(s) may help identify the program or system. For the IRC alert, the port was 6667, a common IRC port. Ports 445 and 135 were used by

Windows hosts for Windows-to-Windows communications, which included RPC (Remote Procedure Call) and DCOM (Distributed Common Object Model) traffic.

Total Alerts - This number gave an idea of how much trouble this host was causing. For example, the Cisco “TCP SYN Host Sweep” alert fired once for every fifteen host scans. This meant that the above 130 alerts for the “TCP SYN Host Sweeps” alert actually represented 1,950 scans; the infected host had scanned 1,950 other hosts looking for systems to infect.

With the information gathered it was possible to make some assumptions regarding these alerts. The scanning suggested the host had been infected with a worm and was actively trying to infect other systems. The worm was probably a part of a bot network that used IRC for command and control over port 6667. When the worm found a Windows host that responded to the TCP SYN packet scan, sometimes referred to as "half-open" scanning, a fast method to scan for hosts (Fyodor), the Windows host tried to infect it via a LSASS RPC overflow, RPC DCOM overflow or a SMB/RPC NoOp sled.

Date of Last Alert - Date (from the sensor) of the last alert activity helped to determine how old the activity was and therefore the chance the user was still on the workstation. The alerts were less than a day old.

Time of Last Alert – The time recorded the last alert activity on that particular host. This was recorded in order to determine how old the activity was and the chance that the user was still on the workstation. In this case, the data was exported from IEV and the report was generated around 1:30 p.m. The last alerts were around 1:20 p.m.

Category - In the example, two categories are listed: Instant Messenger (IM) and Worm\Virus\Trojan. The "IRC Channel Join" alert can be indicative of bot activity. IRC (Internet Relay Chat) was the forerunner and protocol of modern Instant Messaging. The presence of several IRC Channel Join alerts combined with other alerts could mean the workstation had been infected with a worm and was part of a bot network. In this case, the worm turned out to be a Gaobot variant. The Gaobot worm with over 1000 variants and could have exploited several Microsoft vulnerabilities including MS04-011 (LSASS), MS03-001 (RPC Locator), MS03-026 (DCOM RPC) and MS03-007 (WebDAV) (W32/Gaobot.worm.gen 2004).

Internal or External - In this case, the source was scanning and attacking hosts on the Internet. IP address 10.128.9.57 was scanning hosts in the 24.9.x.x IP range. The 24.9.x.x range was registered to "Comcast Cable Communications" and was probably someone's cable modem. Based on a "whois" lookup, the IP range 24.8.0.0 to 24.9.255.255 appeared to be in Colorado.

User Logged into Host at Time Report was Run - This information was collected when the IDS report was run. In many cases, the same person stayed logged on to the same host all day but in this case, since the VPN IP address space was reused after a user disconnected, it was impossible to tell if the computer logged was actually infected. Since the last alert was at 1:20 PM and the report was run at 1:30 PM, it was probable that this was the user and laptop that generated the alerts. Old IDS alert data run through the Perl program may not generate accurate reports.

If a user is logged into an infected system, the user name can be captured via the "nbtstat –A" command. For example:

```
c:\>nbtstat -A 10.28.40.250
Local Area Connection
Node IpAddress: [10.128.40.250] Scope Id: []
    NetBIOS Remote Machine Name Table
    Name               Type         Status  --
HOU001WS1023   <00>  UNIQUE      Registered
COMPANY        <00>  GROUP       Registered
DSMITH         <03>  UNIQUE      Registered
HOU001WS1023   <20>  UNIQUE      Registered
COMPANY        <1E>  GROUP       Registered

    MAC Address = 00-0B-CD-43-90-AF
```

The above was from a Windows host on a NT domain. DSMITH was the user's login name.

NT User Comment Field - Once the user name had been determined, the "net user"

command was used to help identify the individual via the NT "User Comment" field. The User Comment field was from the user's NT domain account details. The company used this field to store information about the user account which made it useful in tracking down the user. While the information in the NT User Comment field was unique to this organization, many organizations add additional information to the user account which can be leveraged to augment the IDS reports.

Date and Time of Last Login - This indicated the date and time the user logged in. This helped show that the user and his laptop were infected with a worm. John logged in at 12:51, the last alerts were around 1:20 and the IDS report was generated around 1:30.

MAC Address of Host - The MAC (Media Access Control) address of the Host that generated the IDS alert. The MAC address of systems on the network was registered with both WINS (Windows Internet Name Service) and DHCP. The IDS report determines the MAC from the output of "nbtstat –A".

Network Card Manufacture - Knowing the network card manufacturer was helpful in tracking down the workstation but not 100% accurate. In this example, the MAC address suggested the system was using an "AMBIT MICROSYSTEMS CORP" network card. While this did not identify the workstation brand, it did imply the workstation was not a HP, Compaq, IBM or Dell since they usually have their own branded network card.

Each Network Interface Card (NIC) in a computer has a unique address called the MAC address which is made up of a 12-digit hexadecimal numbers. The IEEE (Institute of Electrical and Electronics Engineers) assigns the first half of the address to the card manufacturer while the last half of the address is assigned by the manufacturer. ("MAC Address" 2008) Since the MAC is unique and usually static, the MAC helped identify the systems on the network.

Using the list of MACs and manufacturers downloaded from the IEEE web site (http://standards.ieee.org/regauth/oui/index.shtml), it was possible to cross reference the NIC MAC address with the manufacturer via a hash. For example, the following systems generated alerts on 1/21/05.

00-90-27-74-85-66	INTEL CORPORATION
00-02-B3-1D-96-D0	Intel Corporation
00-A0-C9-67-04-84	INTEL CORPORATION - HF1-06
00-D0-59-D9-3F-8B	AMBIT MICROSYSTEMS CORP.
00-02-8A-2B-7B-2A	Ambit Microsystems Corporation
00-06-5B-22-00-E7	Dell Computer Corp.
00-50-04-26-85-4A	3COM CORPORATION
00-0D-87-37-9F-FA	Elitegroup Computer System Co. (ECS)
00-04-AC-D8-69-0D	IBM CORP.
00-09-6B-B0-0F-94	IBM Corporation
00-0B-CD-2B-31-0C	Compaq (HP)
00-50-8B-FB-3E-3C	COMPAQ COMPUTER CORPORATION

00-08-02-32-E0-FE	Compaq Computer Corporation
00-0D-9D-9D-96-5C	Hewlett Packard

Note the “Compaq (HP)” name, a product of the Compaq\HP merger.

Host OS (based on TTL) - The TTL or Time-To-Live value determined how many routers a packet could pass through before the packet was discarded. The TTL was used to identify the operating system. This in turn helped track down the system. It should be noted that most of the workstations on networks today are running Windows 2000, XP or Vista, all of which have a default TTL of 128.

TTL Value	Operating System
128	Windows NT, 2000, XP, 2003, Vista
64	Many Linux and Unix Systems
32	Windows 95, 98 and Millennium Systems

The above are some of the most common operating systems and TTL values. If the organization has more then 32 routers between two systems, the Linux and Unix systems may be interpreted to be Windows 9x systems. The “ping -a -n 1 -w 500” command was used to determine the TTL of the system in question. The “-a” attempted to resolve the hostname while “-n 1” sent just one packet. This organization pinged internal systems on a fast network and used the “-w” switch to timeout the ping in 500 milliseconds. The TTL should not be 100% relied on since the value can be changed but it should work for most computers on the

network. The value reported also gave an idea of how far away the systems were. For example:

*NIX (59)
9x-ME (27)
9x-ME (29)
NT-2000-XP (122)
NT-2000-XP (126)

Site name - Since the Main Data Center managed the VPN IP range, the "Main Datacenter (VPN)" was the site name. The internal network used the private class A address space of 10.0.0.0. A lookup table was used to match the IP address to the physical location based on the first 3 octets of the IP address. This list was read into a hash for easy lookup. For example:

10.106.1.,Northwest - South
10.106.2.,Northwest - Valley
10.128.1.,Datacenter
10.128.9.,Main Datacenter (VPN)
10.131.11.,Corporate – 11th floor
10.131.12.,Corporate – 12th floor
10.131.14.,Corporate – 14th floor
10.131.15.,Corporate – 15th floor
10.133.16., Doctors Hospital – NW Lab

10.133.17., Doctors Hospital – Eastside

Site Contact - Robert Smith was the IDS report contact for the "Main Datacenter (VPN)." A contact that was responsible for IDS follow-up at the site was mapped to each IP subnet. A flat text file and a hash were used for simple site contact lookup. For example:

10.151.6.,Doug Smith
10.151.9., Doug Smith
10.86.15.,Jason Rogers
10.152.9.,Becky Will
10.128.9., Robert Smith

Once the IDS alerts had been identified for follow-up, additional information on the alerts was needed to produce an actionable report. The exact details depended on the needs of the organization; the ones identified above met this organization's needs. Care had to be taken with using DHCP to assign IP addresses since the additional details generated by the Perl program were based on when the report was run, not when the IDS sensor generated the alert. To avoid some of these issues, the report was run on a regular basis, at least once a day during business hours.

5. Following up on the Alerts

The third challenge of IDS in the enterprise was to follow-up on the alerts; this was the most difficult challenge. While the first two challenges were more technical in nature, the third was dependent on the organization, its resources and its politics.

After an actionable report had been generated, it was necessary to determine who would be responsible for following up on the alerts. In a large organization, the group that monitored the IDS is not necessarily the same group that managed the servers and workstations. Additional issues addressed how to handle alerts generated for systems outside the IT area of responsibility. For example some systems were supported by the vendor but on the organization's network. Procedures were developed to track the alerts to resolution. Reports showed alert trending. Guidelines were developed to determine when to try and clean an infected system vs. just re-imaging the system. As the procedures were developed, it allowed the various groups to assign resources to address the alerts more timely.

The desktop support group or the helpdesk may be the best choice for follow-up on alerts produced by workstations. Before investigating alerts there should be guidelines and training so that issues are appropriately dealt with and escalated if needed. The person or

group that responds to the alerts will vary depending on the number and the types of alerts. A single workstation that triggers a spyware alert would command one response while a thousand workstations infected with a worm should trigger a different response.

The policies, procedures and guidelines for addressing the systems that generate alerts should be developed before there is a problem. There should be a policy to work with the vendors responsible for systems that IT is not responsible for. Every system should have an owner and maybe even an IT custodian who is responsible for responding to the IDS alerts and cleaning up the machines. Proactive security measures could include patching and anti-virus updates as well as host based protection like software firewalls.

The person or group responsible for following up and investigating the alert depended on the resources available. For servers in the main data center, the IT custodian of the system was involved as well as the data owner. The system administrator did the initial investigation based on the IDS alert data but the system custodian and system owner had to be informed if the issue was not routine.

Alerts that are generated by systems outside of the responsibility of the internal IT group made up the smallest number of systems but generated the greatest share of the alerts. These systems included portable workstations brought in by consultants, vendors and business partners. There could also be unknown systems that were managed by outside

vendors but connected to the network. The portable workstations were addressed via policies (do not connect unauthorized workstations to the network) and procedures (procedure to authorize the workstations – i.e. after they have been checked & certified clean). Technical means, for example network access control (NAC), should be used to enforce the policies.

Once the report was generated and the party responsible for the system was notified that their system generated a network IDS alert there was mechanism to track the alert for follow-up and resolution. The responsible party documented the alert to resolution. In this organization this was accomplished using the existing work ticketing system. The alert and additional details were entered into the ticket tracking system and assigned to the person or group responsible for the system. The responsible party worked the ticket and entered the details regarding the ticket resolution. The IDS monitoring team then reviewed the completed tickets and in the case of false positives tuned the IDS sensors or modified the filter.

The level of detail and effort expended in tracking the alerts will depend on the resources available. The IDS report distribution and tracking process can begin as an informal process but should mature as time goes by and the staff becomes comfortable responding to the alerts. Closing the loop on alerts is critical for long-term network IDS trending and analysis.

IDS reports should be generated on a regular basis. While 24/7 monitoring is usually

ideal, (no one can move faster then a packet) reports will always be generated after the fact. If the organization is not continually monitoring and reporting on the network IDS, the report should be generated on a regular basis. Generate and distribute the report too often and the staff charged with follow-up will spend all their time investigating the same alerts; if the organization does not generate and distribute the report on regular basis, there could be too many alerts to follow-up on and too many systems compromised. This organization reviewed the IEV in the morning and several times during the day but usually generated the report only in the afternoon so there was still time in the day to address any systems that needed immediate follow-up.

With multiple building and sites, reports were generated per location using the IP address of the systems generating the alerts. These were then distributed to the local IT staff charged with the responsibility for the local systems.

Weekly or monthly trending was done in order to ensure the alerts were being addressed. Those trending reports were useful in several ways. They demonstrated the effectiveness of network IDS monitoring to management and helped justify additional sensors or sensor placement. Trending reports included all alerts captured, not just the alerts that passed through the filter. These reports were used to improve the effectiveness of the filter by adding and subtracting alerts.

Incident response and handling is outside the scope of this paper but there should be some guidelines if not policies and procedures for incident handling for the IDS alerts. Each organization must determine how they plan to deal with the most common alerts and to what extent. For example, should spyware just be removed from workstations or should it be investigated? Should a workstation be re-imaged if a worm is found or only if the worm can not be removed? When should a revenue generating production system be taken off line in order to remove the worm and patch the system? Who should make that call? If a breach may have resulted in exposing customer, employee or health records, when should Human Resources or the Compliance departments become involved? What is the protocol if pornography is discovered on a workstation that is also infected with multiple viruses? When is law enforcement called? What evidence is preserved? How is it preserved? What about the discovery of pirated movies, MP3s or software discovered on a workstation? Who should be notified, how and when should it be done?. These are important questions to consider before an event occurs.

6. Program Improvements

The Perl program can be improved. The IEV alert data export process was a manual process. It would be useful if the program could be automated to query IEV's MySQL database and then configured to generate reports on a regular basis. It takes several minutes

or longer to process the IEV alert data. This is due to the use of the 'ping' and 'nbtstat' commands to gather additional information. If the process could query the domain controllers for the same information, the program's performance would improve. The program output is in CSV files. While it takes only a few minutes to sort the data and then paste into a spreadsheet template, the reports should be produced in Excel format. Report distribution was a manual process but could have been automatically sent to the ticketing system or even emailed automatically. The Perl program served the purpose for which it was designed. It turned tens of thousands of alerts into an actionable report that could be followed-up on by the appropriate people.

7. Conclusion

A network IDS can play an important security role in an organization but only if the number of alerts can be managed. The most important alerts must be identified, reported and followed up in a timely and organized way. Monitoring the IDS gave insight to the network but generated a great deal of alerts which required follow-up. Organizations that implement an IDS should be prepared for the additional resources required to monitor and follow-up. By creating an actionable IDS report and reacting to a predefined set of alerts, an organization

can better manage the resources required for the IDS response.

8. References

Axelsson, S. (1999, May 20). *The Base-Rate Fallacy and its Implications for the Difficulty of Intrusion Detection* Retrieved March 16, 2008, from http://www.raid-symposium.org/raid99/PAPERS/Axelsson.pdf

Beaver, K. (2003, September 23). *Does spyware and adware qualify as 'malicious software' under the HIPAA rules?* Retrieved January 28, 2008, from http://searchsecurity.techtarget.com/expert/KnowledgebaseAnswer/0,289625,sid14_gci930265,00.html

Carter, E. (2002, February 15). *Intrusion Detection Systems* Retrieved March 17, 2008, from http://www.ciscopress.com/articles/article.asp?p=25334

Fyodor (n.d.). *Port Scanning Techniques* Retrieved March 16, 2008, from http://nmap.org/man/man-port-scanning-techniques.html

Cisco (2003). *How Cisco IT Upgraded Intrusion Detection to Improve Scalability and Performance*. Retrieved January 28, 2008 from http://www.cisco.com/web/about/ciscoitatwork/downloads/ciscoitatwork/pdf/cisco_ids4250_casestudy.pdf

Innella, P. (2001, November 16). *The Evolution of Intrusion Detection Systems*. Retrieved January 28, 2008, from http://www.securityfocus.com/infocus/1514

MAC address (n.d) Retrieved March 16, 2008, from http://en.wikipedia.org/wiki/MAC_address

Meyer, R. (2008, March 12). *Actionable IDS Reports* Retrieved March 12, 2008, from http://sourceforge.net/projects/actionableids/

Newman, D, Snyder, J, Thayer, R. (2002, February 24). *Crying wolf: False alarms hide attacks* Retrieved March 15, 2008, from http://www.networkworld.com/techinsider/2002/0624security1.html

W32/Gaobot.worm.gen (2004, May 16). Retrieved March 16, 2008, from http://vil.nai.com/vil/Content/v_100785.htm

Wilson, T. (2007, June 12). *Pfizer Falls Victim to P2P Hack*. Retrieved January 28, 2008, from http://www.darkreading.com/document.asp?doc_id=126297

Last Updated: February 24th, 2018

Upcoming SANS Training

Click Here for a full list of all Upcoming SANS Events by Location

CyberThreat Summit 2018	London, GB	Feb 27, 2018 - Feb 28, 2018	Live Event
SANS London March 2018	London, GB	Mar 05, 2018 - Mar 10, 2018	Live Event
SANS Secure Osaka 2018	Osaka, JP	Mar 12, 2018 - Mar 17, 2018	Live Event
SANS San Francisco Spring 2018	San Francisco, CAUS	Mar 12, 2018 - Mar 17, 2018	Live Event
SANS Paris March 2018	Paris, FR	Mar 12, 2018 - Mar 17, 2018	Live Event
SANS Secure Singapore 2018	Singapore, SG	Mar 12, 2018 - Mar 24, 2018	Live Event
SANS Northern VA Spring - Tysons 2018	McLean, VAUS	Mar 17, 2018 - Mar 24, 2018	Live Event
ICS Security Summit & Training 2018	Orlando, FLUS	Mar 18, 2018 - Mar 26, 2018	Live Event
SANS Munich March 2018	Munich, DE	Mar 19, 2018 - Mar 24, 2018	Live Event
SEC487: Open-Source Intel Beta One	McLean, VAUS	Mar 19, 2018 - Mar 24, 2018	Live Event
SANS Pen Test Austin 2018	Austin, TXUS	Mar 19, 2018 - Mar 24, 2018	Live Event
SANS Secure Canberra 2018	Canberra, AU	Mar 19, 2018 - Mar 24, 2018	Live Event
SANS Boston Spring 2018	Boston, MAUS	Mar 25, 2018 - Mar 30, 2018	Live Event
SANS 2018	Orlando, FLUS	Apr 03, 2018 - Apr 10, 2018	Live Event
SANS Abu Dhabi 2018	Abu Dhabi, AE	Apr 07, 2018 - Apr 12, 2018	Live Event
Pre-RSA® Conference Training	San Francisco, CAUS	Apr 11, 2018 - Apr 16, 2018	Live Event
SANS Zurich 2018	Zurich, CH	Apr 16, 2018 - Apr 21, 2018	Live Event
SANS London April 2018	London, GB	Apr 16, 2018 - Apr 21, 2018	Live Event
SANS Baltimore Spring 2018	Baltimore, MDUS	Apr 21, 2018 - Apr 28, 2018	Live Event
SANS Seattle Spring 2018	Seattle, WAUS	Apr 23, 2018 - Apr 28, 2018	Live Event
Blue Team Summit & Training 2018	Louisville, KYUS	Apr 23, 2018 - Apr 30, 2018	Live Event
SANS Riyadh April 2018	Riyadh, SA	Apr 28, 2018 - May 03, 2018	Live Event
SANS Doha 2018	Doha, QA	Apr 28, 2018 - May 03, 2018	Live Event
SANS SEC460: Enterprise Threat Beta Two	Crystal City, VAUS	Apr 30, 2018 - May 05, 2018	Live Event
Automotive Cybersecurity Summit & Training 2018	Chicago, ILUS	May 01, 2018 - May 08, 2018	Live Event
SANS SEC504 in Thai 2018	Bangkok, TH	May 07, 2018 - May 12, 2018	Live Event
SANS Security West 2018	San Diego, CAUS	May 11, 2018 - May 18, 2018	Live Event
SANS Melbourne 2018	Melbourne, AU	May 14, 2018 - May 26, 2018	Live Event
SANS Northern VA Reston Spring 2018	Reston, VAUS	May 20, 2018 - May 25, 2018	Live Event
SANS New York City Winter 2018	OnlineNYUS	Feb 26, 2018 - Mar 03, 2018	Live Event
SANS OnDemand	Books & MP3s OnlyUS	Anytime	Self Paced