Global Information Assurance Certification Paper

Perimeter Defense-in-Depth with Cisco ASA

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Outline

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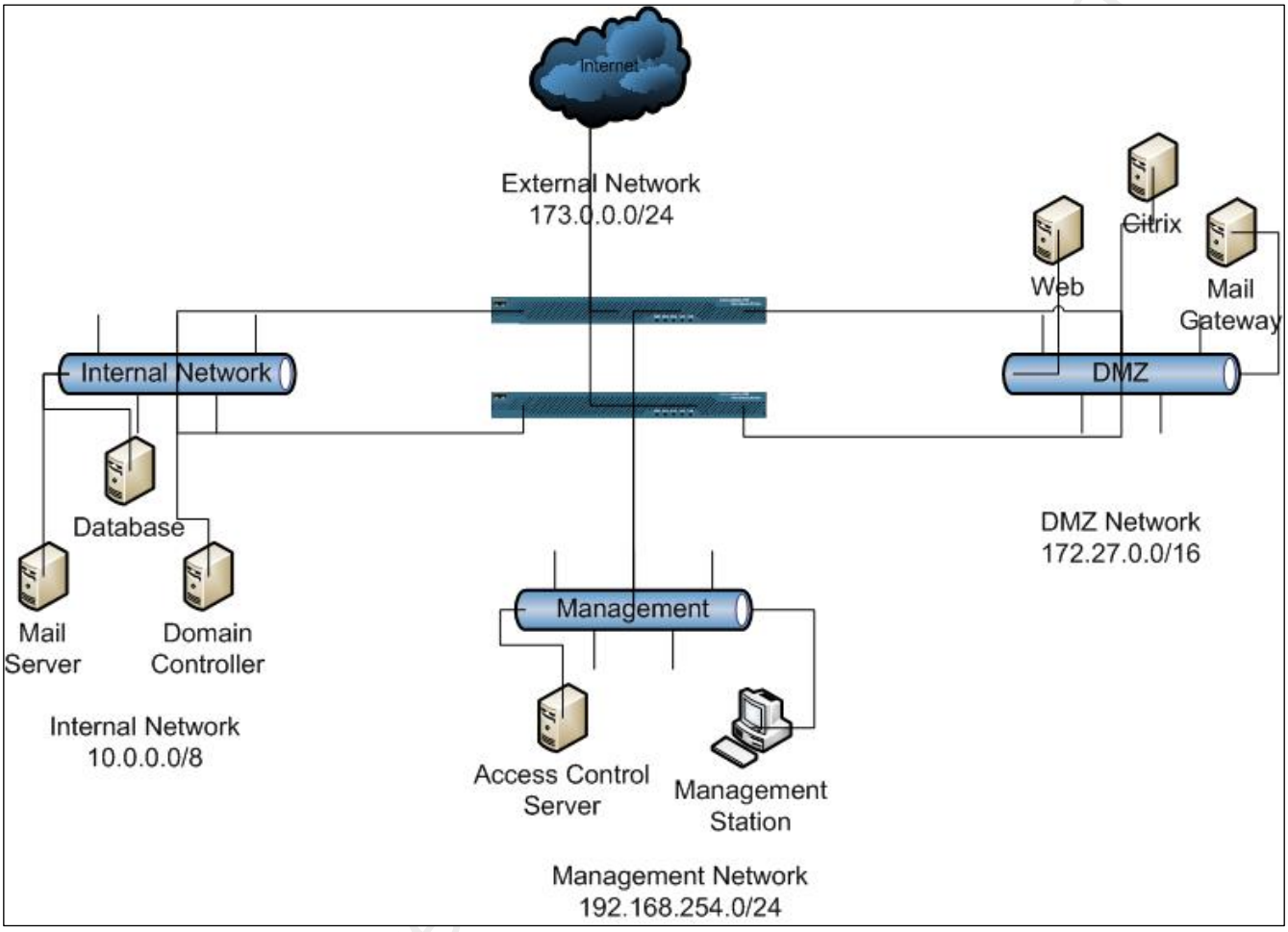
1 Introduction

No matter how tightly locked down one keeps one's internal systems, how religiously the system administrators apply patches, and how well educated about network threats the user base becomes, a weak perimeter security system turns an otherwise secure system into a castle with an empty moat. The challenges of securing this system expand geometrically when faced with shrinking IT budgets and a demand from upper management to accomplish more with less. No longer can one deploy separate VPN, IDS and firewall modules; costs for rack space, power consumption, and the equipment itself spiral ever upwards. Many vendors recognize this issue, especially during a shrinking economy. Cisco's solution to this is the Adaptive Security Appliance (ASA), "[i]ncorporating all of these solutions into Cisco ASA secures the network without the need for extra overlay equipment or network alterations"(Frahim and Santos, 2006, p. 33).

Over the course of this document, the reader will learn what to do to use the ASA

security device for perimeter security, why these choices would be made, what best practices are, and business justifications for each of these decisions. By the end, a network security engineer should be able to successfully deploy a Cisco ASA to harden the perimeter of the network, and reduce the threat profile of the business. This document assumes basic understanding of networking and concepts. It further assumes that an ASA is protecting the border of the network in its basic "out of the box" configuration, including an IP address on each the inside, outside, and a DMZ network, static routing to the Internet, and no ingress or egress filters in place. Figure 1-1 shows the network diagram that will be the basis for the examples.

Figure 1-1 – SANSecure network topology



There are multiple phases to configuring the ASA to be the center of the perimeter security puzzle. The three main topics will be firewall, intrusion detection / prevention system (IPS), and virtual private network concentrator (VPN).

2 Firewall

2.1 Border Considerations

Before embarking on establishing a secure firewall, a hardened perimeter must begin at the border router. One must remember that there are three parts to the security triad: confidentiality, integrity, and availability. While most of the works on security focus on the first two, without the latter, they are not as useful. Therefore, one must prepare against Denial of Service (DoS) and Distributed Denial of Service (DDoS) attacks. Working with one's ISP, it is possible to diminish greatly the potential for damage due to DDoS attacks. While there are tools in the ASA that will help with DoS attacks, the fight against them must begin at the ISP. One should encourage one's ISPs to enact RFC 2827 filtering on all of their upstream devices, "it will prohibit an attacker within the originating network from launching an attack of this nature using forged source addresses that do not conform to ingress filtering rules" (Ferguson, 2000). Furthermore, as more ISPs enable RFC 2827 filtering on their network, an additional benefit arises, as noted in the RFC, "An additional benefit of implementing this type of filtering is that it enables the originator to be easily traced to its true source, since the attacker would have to use a valid, and legitimately reachable, source address" (Ferguson,

2000).

The business case for this is almost self-evident. Encouraging the upstream ISP to filter out obviously false IP addresses can prevent aspects of a DoS without waiting to flood the incoming pipe and filter at the border router. If enough of their clients request it, they can become leaders in Internet security by providing this service by default; this helps to reduce threats to their clients, and therefore they can charge a premium. It reduces the bandwidth requirements of the individual businesses, as spoofed traffic cannot make it as far as the CPE in the first place.

To implement RFC 2827 filtering, one must start by eliminating inbound traffic from RFC 1918 addresses. These are private, non-routable IP addresses that should never appear on the outside interface of a router. These are defined as follows:

- 10.0.0.0/8
- 172.16.0.0/12
- 192.168.0.0/16

(Rekhter, Moskowitz, Karrenburg, de Groot, & Lear, 1996). Further limitation on inbound IP addresses can be found in RFC 2365, and prevents spoofed multicast from the “private” range of 239.0.0.0/8 (Meyer, 1998). These addresses should never cross administrative

boundaries, so a multicast address in that range coming inbound must be spoofed. Finally, one can also eliminate any IANA reserved addresses (IANA, 2009). These IP addresses include the following:

- 0.0.0.0/8
- 127.0.0.0/8
- 169.254.0.0
- 192.0.2.0/24

Unless there is a compelling reason, the multicast range of 224.0.0.0/8 should also be blocked at the ISP, or, if they will not, at the border router. Lastly, the broadcast address of 255.255.255.255 should be blocked, to prevent certain kinds of DoS attacks. This covers the "standard" IP addresses that should be blocked on the ISP routers. There is one last line that needs to be included in the access list, however, and that is a line that prevents any traffic with a source that is the same as the destination network from traversing the router, as this is also, quite obviously, spoofed.

One might ask how preventing these networks from reaching the CPE would prevent a DoS or DDoS attack. One feature in many DoS attacks is exhaustion of resources; a Web server, for example, can only accept so many half-open TCP connections before it fails

(known as a SYN Flood attack) (Cole, 2002). However, if a SYN packet is sent with a spoofed source that will respond with a TCP RST to a received, unsolicited SYN-ACK, then the DoS will not work, because that resource will be freed up. Therefore, many DoS tools prefer to use reserved addresses for the spoofed sources; thus the effectiveness of the RFC 2827 filter. The command syntax for applying this filter to the CPE border router is listed below (assuming a Cisco router on the border). The external IP address range is taken from figure 1-1, to illustrate. One caveat is that, depending on the design of one's network, it may be required to permit access from the upstream router in the same network as the advertised network, to prevent loss of connectivity from the ISP. That exception would be near the top of the access list.

Example 2-1: Anti-Bogon Access List

```
access-list 199 deny ip 0.0.0.0 255.255.255.255 any log
access-list 199 deny ip 10.0.0.0 0.255.255.255 any log
access-list 199 deny ip 127.0.0.0 0.255.255.255 any log
access-list 199 deny ip 172.16.0.0 0.15.255.255 any log
access-list 199 deny ip 169.254.0.0 0.0.255.255 any log
access-list 199 deny ip 192.0.2.0 0.0.0.255 any log
access-list 199 deny ip 192.168.0.0 0.0.255.255 any log
access-list 199 deny ip 224.0.0.0 0.0.0.255 any log
access-list 199 deny ip 239.0.0.0 0.255.255.255 any log
access-list 199 deny ip 255.255.255.255 0.0.0.0 any log
access-list 199 deny ip 173.0.0.0 0.0.0.255 any log
access-list 199 permit ip any any
```

Once the access list is created, it must be applied to the outside interface of the border router (or to the non-customer facing interfaces of the ISP router, if one's ISP is amenable to such protection for its clients.) As an example, this will be placed on the S0/0 interface of the border router for the SANSecure network.

Example 2-2: Configuring an Access List on an Interface

```
interface s0/0
    ip access-group 199 in
```

This applies the access list in the inbound direction of the outside interface, preventing known spoofed traffic from entering the network.

2.2 Interface and Management Configuration

Every interface on the ASA can have a different security level. These security levels can reflect the level of trust assigned to an interface (Frahim & Santos, 2006, p. 60). By default, traffic from a higher security (more trusted) interface to a lower security (less trusted) interface can flow freely, unless an access list is enabled to deny it. The ASA also allows for information to flow between two interfaces of the same security level using the **same-security-traffic permit inter-interface** command.

One often-overlooked interface, however, is the management interface. Frequently, implementers will simply use the Inside interface as the management interface, since it is already reachable by internal means. The management interface (M0/0), however, is the better choice for this. This interface does not route, and it will only accept traffic destined to the device itself, not traffic destined for other networks (Frahim & Santos, 2006, p.65). This interface can support routing protocols, however, so that it can be set as a peer with other routers in the network – this is especially useful in a well-designed network which has a separate management VLAN that is used to access administrative functions for all network

devices in the enterprise.

When configuring the management interface, it's also a good plan to take this time to lock down available protocols and hosts for managing the device. Ideally, all management would take place from a single station on the network (a "jump server" situated in the management network) which requires strong authentication and allows for limited access to it. In figure 1-1, that is the workstation, and its IP, for the purposes of this document, is 192.168.254.2, with the management IP of the ASA being 192.168.254.1. Ideally, when one speaks of management protocols allowed to the ASA, one needs to be aware of the inherent insecurity involved in some of these. The first problem we encounter is telnet – it transmits all communications in clear text, including usernames and passwords. Therefore, we need to disable telnet completely. The next issue we face is weaknesses in SSH1 which allow for possible cryptographic exploitation. Lastly, anyone who has used Cisco equipment for a long time is familiar with the need for TFTP and the vulnerabilities inherent within, including clear text transfer of data – not a useful item when one is trying to back up or restore the configuration of a firewall. Fortunately, these can all be mitigated.

The ASA allows management through three protocols to alleviate these symptoms. First, one can manage the device over HTTPS using the Adaptive Security Module (ADSM). This friendly, helpful GUI is the antithesis of previous incarnations of Cisco GUIs in that it is

useful and powerful. Other portions of this document will explain its use. This communication is secured through an SSL connection, and a self-signed certificate. The next mitigation is the use of SSH v2, which removes many of the insecurities of the previous version. Lastly, one can use secure copy (SCP) rather than TFTP to transfer files to and from the ASA, including the OS and config files (Abelar, 2005).

In order to limit these activities, one would use the commands in example 2-3 below. In this example, we demonstrate the creation of a 2048-bit RSA key (used to encrypt communications for an SSH tunnel), enabling SSH version 2, enabling SCP, limiting the time an SSH session can be idle, locking down access to permit only the management station for SSH and HTTPS, and disabling telnet.

Example 2-3: Configuring Management Security

```
crypto key generate rsa modulus 2048
ssh version 2
ssh scopy enable
ssh timeout 5
ssh 192.168.254.2 255.255.255.255 management
http 192.168.254.2 255.255.255.255 management
```

This effectively limits administrative control over the device to a single workstation, by a pair

of protocols. As mentioned previously, one can also backup and restore configurations via the SCP method, alleviating the worry of interceptions of TFTP transit.

Ensuring proper login authentication, authorization, and accounting becomes the next sequence of events with which one must contend. ASA's can use multiple different sources for AAA services, Cisco's preference being the use of Cisco Access Control Server, and the TACACS+ protocol. While each environment is different, the one constant is that one must not use the default username (pix) and default enable passwords for management of one's perimeter device. The examples in this document will focus on using the local user database inside the ASA; however, an ideal situation involves pairing up with a TACACS+ or RADIUS server, as that allows for integration with the enterprise's authentication databases.

In order to use AAA, one must create users, and then determine their level of access. The minimum requirement for best practices states that all users must log on with a unique username and all access must be logged. (Logging will be covered later in this document.) While different access levels can have different commands assigned to them, the only two command levels that come pre-defined in the ASA are level 1 (which cannot even enter enable mode) and level 15 (which has full administrative access). Each individual user in the database can be set at one of these levels (or any others that the administrator cares to define), and all actions will be logged with that person's username. In order to secure the

environment, we must use the **aaa authentication** command, as follows demonstrated in example 2-4.

Example 2-4: Configuring AAA Authentication

```
username SANS password Pe<gJp6v privilege 15
aaa authentication ssh console LOCAL
aaa authentication serial console LOCAL
aaa authentication http console LOCAL
aaa authentication enable console LOCAL
```

The **console LOCAL** designation delineates that the local user database is to be queried for any authentication request. Multiple authentication methods can be used if they are defined, and they will cascade down in the event of error (not authentication failure) from the authentication server. For example, if a TACACS+ server is defined, and one uses **aaa authentication enable console TACACS+ LOCAL**, then the local user database would *only* be polled if the TACACS+ server were unreachable (Morgan & Lovering, 2008, p.502).

The final management concern of the ASA is proper logging configuration. This is best accomplished through Syslog for the vast majority of alerts, with some specialized alerts being sent via Email to administrators in the case of emergencies, to reduce time before discovery of the issue. Obviously, some sort of Syslog message receiver needs to be in place. Ideally, one would contract with a managed security service provider (MSSP) to

aggregate and correlate the received logs, as it is more cost efficient to outsource log analysis to such a firm.

The first piece of the logging puzzle is ensuring proper timestamps on the device. To do this, one should configure NTP, using the appropriate nearest interface as the source address. If the NTP server requires authentication, an authentication key can be configured. When using a common Internet time server, however, trust is not configured. It is preferable to use a time server located in the enterprise's internal network, to ensure that all clocks are synchronized at the same stratum. Example 2-5 demonstrates connecting to a Microsoft Windows domain controller for network time, with no authentication, as it is not supported by the Microsoft Windows time server.

Example 2-5: Configuring an NTP Server

```
ntp server 10.0.1.1 source inside prefer
```

If the enterprise is running an NTP server that uses a newer version of NTP that can use MD5 authentication, it is highly recommended to do so. In such a case, example 2-6 would configure such a key (Frahim & Santos, 2006, p.74). The time updates will be stamped with an MD5 hash, to ensure authenticity.

Example 2-6: Configuring NTP Authentication

```
ntp authentication-key 123 md5 cisco123
ntp authenticate
ntp server 10.0.1.2 source inside key 123
```

Once NTP is enabled, the device is ready to begin logging. The things that the enterprise must decide are the recipient host, the method of transmission, and which logs to email to administrators. The **logging host** command dictates the device which will receive the logs. The device uses UDP port 514 for Syslog by default, however, should one decide to use TCP Syslog, the device can do that, as well. Because there is a possibility of TCP connections jamming up, the recommendation is to stick with UDP Syslog if the packets will remain on a secure network. (Note: TCP Syslog will not automatically encrypt the packets, but it will obfuscate them somewhat.) It is considered a best practice to set the log level to debug, and have a very good back-end parsing system for the logs (or hire an MSSP), so that important logs are not missed.

Example 2-7: Configuring Syslog

```
logging enable
logging host management 192.168.254.3
logging trap debug
```

Next, email alerts need to be configured. These are for emergencies that cannot wait for an analyst to receive the event and parse it. A logging list is used to determine the types of logs

to be sent. In example 2-7, a logging list called Email_Alerts is created to send Error and higher level events via email for selected event classes. A full list of logging classes can be located at http://www.cisco.com/en/US/docs/security/asa/asa80/command/reference/l2.html#wp1754683.

Example 2-8: Configuring Email Logging

```
smtp-server 10.0.0.4
logging list Email_Alerts level error class auth
logging list Email_Alerts level error class config
logging list Email_Alerts level error class ha
logging list Email_Alerts level error class np
logging list Email_Alerts level error class sys
logging from-address ASA_perimeter_01@sansecure.fake
logging recipient-address IncidentHandlers@sansecure.fake level informational
logging mail Email_Alerts
```

This configuration will send the error level or above alerts regarding authentication, configuration, failover, network processor, and system events to the incident handlers at SANsecure for immediate attention.

2.3 NAT and Spoofing

The ASA grew out of the old Cisco PIX, which required address translations for any traversal of an interface. While identity NAT could be used (with the **nat (interface) 0**

command), there was no way to, by default allow packets to route through the firewall un-translated. Starting with the ASA (and PIX 7.x), one can turn off NAT control, allowing packets to traverse the network unaltered. This is useful if one does not wish to use RFC 1918 addresses on DMZ servers, instead using the globally routable network addresses on the boxes themselves, or if the enterprise is using globally routable IP addresses throughout the network, a practice that this author strongly discourages. There are two directions for translation – from lower security interface to a higher one, and the reverse.

When arriving on an interface destined for a higher security interface, a packet must be statically translated. The static command uses the following syntax:

static (real_interface,mapped_interface) {mapped_IP} {real_IP [netmask mask]} [**dns**] [**norandomseq**] [[**tcp**] [max_conns [embryonic_limit]] [**udp** udp_max_conns]

This is best served up with an example, as in 2-8.

Example 2-9: Configuring a Static Translation

```
static (dmz,outside) 173.0.0.4 172.27.1.4 netmask 255.255.255.255 dns tcp 1000 100
udp 1000
```

With this example, a DMZ server at 172.27.1.4 is translated to 173.0.0.4 on the globally

routable network. DNS replies matching that IP address that come through the firewall are automatically translated, to prevent the need for split-brain DNS. (Since traffic cannot re-enter the interface that it exits, if the DNS for www.sansecure.fake was 173.0.0.4, and an internal user wanted to access it, the request would fail. With DNS rewrite, the DNS packet coming back from an external DNS server would change the response to say 172.27.1.4, and the internal host would be able to route to it.) Furthermore, it sets a maximum number of 1000 TCP and UDP connections to the device, with 100 "half-open" TCP connections, which have not yet received an ACK back from the SYN-ACK. This helps prevent denial of service attacks by reducing resource usage on half-open connections. The **norandomseq** option is potentially insecure, and should only be used if the expected protocol traversing the connection is hostile to the idea of randomized sequence numbers, such as BGP (Frahim & Santos, 2006, p. 160).

Outbound NAT works similarly. As stated earlier, it is assumed that the device is already passing traffic, so there is already a **nat** and **global** statement at work in the configuration. Best practices state that the outside interface of the firewall is not to be used as the global hide NAT, to help ensure the stealth of the firewall. Instead, one should create different NATs for each specified group attempting to reach the lower security network. Example 2-9 demonstrates this.

Example 2-10: Configuring NAT

```
nat (inside) 1 0.0.0.0 0.0.0.0
nat (dmz) 2 0.0.0.0 0.0.0.0
global (outside) 1 173.0.0.2
global (outside) 2 173.0.0.3
```

Note that the designation on the **global** statement corresponds to the numerical designator on the **nat** statement. This configuration allows for Internal and DMZ networks to be PATted to different IP addresses, preventing overlap and confusion. Furthermore, it helps to narrow down the culprits if there is a networking issue to solve – if the IP address being reported is 173.0.0.3, one knows that it is a host on the DMZ network causing the issue, and investigation of the logs can be further refined.

Once it is decided how traffic will traverse the firewall, it is important to determine which networks should be allowed to hit which interfaces. While the border router is going to control some of the spoofing, it is important that the firewall observe proper anti-spoofing rules as well. For example, if one had two DMZ networks, one with 172.16.0.0/24 and one with 172.16.1.0/24, a B2B partner on the 172.16.1.0/24 network could, conceivably, spoof the 172.16.0.0/24 network, and compromise security and information if the anti-spoofing is not properly configured. Fortunately, the ASA can handle this natively. The **ip verify reverse-path interface** command controls this (Understanding Unicast Reverse Path Forwarding, 2007). It

is considered a best practice to enable this on all interfaces. The following example shows the configuration of the SANSecure ASA:

Example 2-11: Configuring Reverse Path Verification

```
ip verify reverse-path interface inside
ip verify reverse-path interface outside
ip verify reverse-path interface dmz
```

The ASA consults the routing table on any inbound packet, to determine whether or not the packet is spoofed. Regardless of whether the routing table is populated through static or dynamic protocols, the incoming packet is examined to determine if the interface on which it was received is the same as the interface that the firewall would use to route back to that network. If these do not match, the packet is discarded, regardless of the filtering rules. As this feature is not enabled by default, it is prudent for the network administrator to enable it.

2.4 Packet Filtering

An ASA without access lists defined is essentially a very expensive router. Granted, the default configuration automatically secures a network against malicious inbound packets, but there are far more dangers on the Internet than simply blocking inbound traffic can avoid.

Ingress filtering is fairly obvious and straightforward. By default, all ASA access lists end with an implicit “deny all” statement – anything that is not explicitly permitted earlier in the

access list is dropped. (This is known as a “default-deny” model.) Unfortunately, from an analysis perspective, that implicit deny all is not helpful when determining if someone is “rattling the doorknobs” to attempt reconnaissance scanning. Therefore, all access lists should end with the line **access-list** *listname* **deny ip any any**. This will cause the implicit deny at the end of the access list to become an explicit deny, and will send a log to whichever log receiver is configured for the device.

The basic tenets of ingress filtering are simple: one must determine which services one wishes to expose to the Internet. For a web server, that may be HTTP and HTTPS, for a mail server, it may only be SMTP. Best practices dictate that one should create a list of all servers in the DMZ, which services one will expose, and only allow those ports and protocols inbound to explicitly those machines. The effort involved in this information gathering is trivial, the impact is enormous. Furthermore, best practices further dictate that there is never a direct inbound connection originating from the Internet to an internal host. In keeping with the default-deny model, one adds the access list elements that will be permitted explicitly to the list above the deny all statement, and a fairly locked-down ingress-filter is created.

Egress filtering is a far more complicated situation, and, consequently, is frequently ignored by businesses in today’s environment. Sadly, this leads to many compromises which could otherwise have been avoided. For example, if a Web server in the DMZ is not allowed

to connect outbound at all, then an attacker running a remote buffer overflow exploit which allows them to connect outbound, pull down a bot, and start spamming or worse becomes moot. Certainly the remote exploit may cause a denial of service against the service being exploited, but the enterprise gains two advantages with the egress filter: logs generated showing that one of the web servers is attempting to connect outbound (which should raise a red flag for the analysts), and prevention of liability caused by one's network being used as a jump-off point in an attack (Distler, 2008). Preventing one's company from leaking information, being used in a Denial of Service attack, or being part of a botnet are all strong financial motivators for management to approve the time investment in correctly configuring egress filtering. Methodology for determining the types of packets which will be allowed through the egress filter is beyond the scope of this work; for a more in-depth analysis, consult Dennis Distler's 2008 paper, "Understanding Egress Filtering."

Once one has a list of the hosts, protocols, and ports that will be allowed in and out, one must then start building the access control list that will determine the packet's ability to traverse the firewall. Again, this document assumes some familiarity with the ASA, so the majority of features in the access list command will not be covered in detail here. The syntax for the access-list statement is as follows:

access-list *id* [line *line-number*] [**extended**] [**line** *line-number*] {deny | permit} {*protocol* | **object-group**

protocol_obj_grp_id} {*src_ip mask* | **interface** *ifc_name* | **object-group** *network_obj_grp_id*} [*operator port* | **object-group** *service_obj_grp_id*] {*dest_ip mask* | interface *ifc_name* | **object-group** *network_obj_grp_id*} [*operator port* | **object-group** *service_obj_grp_id* | **object-group** *icmp_type_obj_grp_id*] [**log** [[*level*] [**interval** *secs*] | **disable** | **default**]] [**inactive** | **time-range** *time_range_name*]

One can easily see that the access list can quickly become complicated. To alleviate this, one can employ several methods. The first, and best, is the object-group method. One creates object groups for every possible grouping that makes sense. For example, if one has multiple web servers, create a network-object type for them. If there's a certain set of ports going to a single server, or group of servers, create a service group for those. In the past, service object groups could not mix – one needed a separate group for ICMP, TCP, UDP, and IP protocols. More recent versions of the ASA code allow for mixed type groups, such as in the following example.

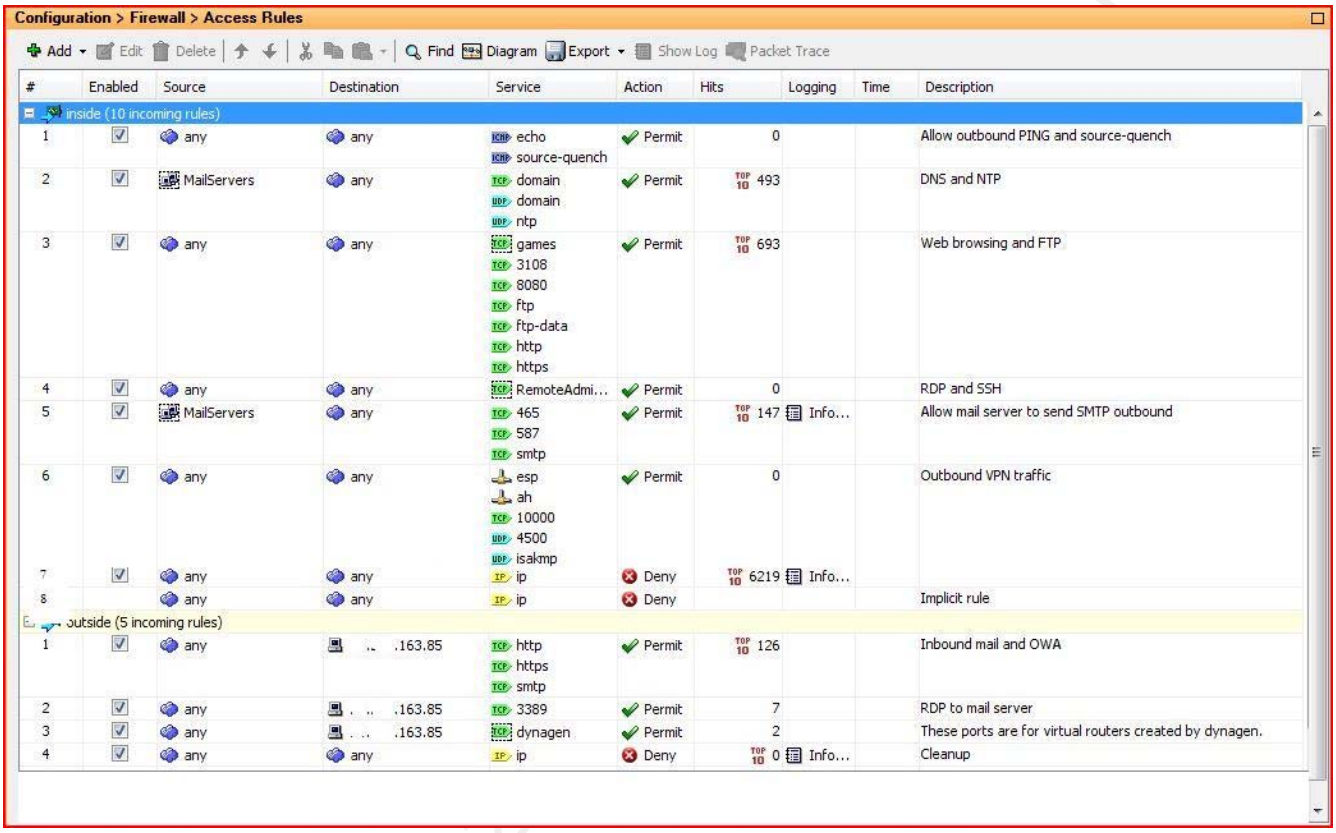
Example 2-12: Service Group Objects

```
object-group service DNS
   service-object udp eq 53
   service-object tcp eq 53
```

The best practice is to use groups almost exclusively, adding a host object to a rule where all

the ports match, or adding a port to a rule where all the hosts match. The problem with this approach is that it soon becomes unwieldy. Fortunately, recent versions of ASA use the ASDM (Adaptive Security Device Manager) – a marked departure from the old PDM (PIX Device Manager) in that it is user-friendly, powerful, and effective. Using the ASDM firewall rules screen, one can view rule sets graphically, seeing which rules have the highest levels of activity, which rules might need to be deleted, and view the comments on each rule. Notice that in Figure 2-1, each service can easily be seen, and to and from which hosts the services are allowed. There are also markings for the "top 10" most used rules – this allows for rulebase optimization and tuning – the most frequently used rules should appear at the top of the list, providing that moving it doesn't nullify anything it was intended to secure, so that the load on the processor is decreased. It is important to note that the "top 10" designation is over the previous hour, not since the last time the firewall was rebooted; it is incumbent upon the firewall administrator to determine the appropriate weight to give each rule based on the time of day and expected usage.

Figure 2-1: Rulebase in ASDM



One important, but often overlooked, aspect of filtering is ICMP filtering. For all of its importance in the Internet, and the TCP/IP protocol suite in general, relatively few network engineers have a solid understanding of ICMP filtering. "ICMP security can be a very lengthy discussion because lots of nasty things can be done with ICMP messages when scanning networks or trying to gain a covert channel" (Convery, 2004). There are a few message types which should be allowed to traverse your network; the rest, however, can safely be dropped at the perimeter.

The first ICMP protocols which must be enabled are echo-request and echo-reply. The caveat to this is that echo-reply messages must be allowed to return through the perimeter firewall if and only if there is a corresponding echo request sent outbound. This is completed with the **ip inspect** command, covered in section three; for now, it is an acceptable practice to allow ICMP echo-request outbound through the filter, and allow the protocol fixups to handle the returning echo-reply.

The next category of ICMP messages contains the various "unreachable" codes. Sadly, ASA code, as of this writing, does not differentiate between the various unreachables; one must allow all or none. It is best to allow at the border router any "fragmentation needed but DF bit set" with the command **access-list 199 permit icmp any any packet-too-big** (assuming that the egress filtering ACL on the border router is numbered 199), and allow the unreachables through the ASA. This way, an internal router requiring fragmentation can tell upstream hosts to shrink the MTU on the packet, while, at the same time, preventing the transmission of reconnaissance data to a potentially malicious host (Convery, 2004). All other ICMP should be dropped at the ASA and the border router.

While the Cisco ACL schema can be a powerful tool, there is a strong possibility for the access lists to become confusing quickly. Scanning through thousands of lines of ACLs, filtering large groups to determine proper membership, examining rule order – these things

can leave a firewall administrator disoriented and annoyed. The best workaround for this is to use the ASDM. It borrows heavily from the Check Point GUI model which allows one to drag and drop hosts, and list the services separately in the same rule. While the back-end system will still treat the rulebase as it always has, this allows for much more readable rulebases for the administrator to manage.

2.5 URL and Content Filtering

The Cisco ASA cannot natively filter URLs; it must rely on the services of WebSense or N2H2 for that. However, it can be configured to send packets to the filter based on the ruleset, and drop the appropriate connections. Best practices dictate that an organization must have a URL filtering server, to prevent employees from creating a hostile work environment by visiting sites which are against company policy, and to reduce the amount of time that employees spend in non-work-related web surfing.

To configure URL filtering, one must first define a URL server. The syntax for this is as follows:

url-server (*if_name***) vendor websense host** *local_ip* **[timeout** *seconds***] [protocol TCP|UDP [version 1|4] [connections** *num_conns***]]**

url-server (*if_name***) vendor smartfilter|n2h2 host** *local_ip* **[port** *number***] [timeout** *seconds***] [protocol TCP|UDP [connections** *num_conns***]]**

The organization should select the appropriate vendor's implementation, and configure the URL server with that line. In the SANSecure example, the WebSense server hangs off of the management network at 192.68.254.12, and would be configured as in example 2-12.

Example 2-13: Configuring a WebSense Filter Server

```
url-server (management) vendor websense host 192.168.254.12 timeout 30 protocol      TCP
    version 4
```

Once a filtering server is defined, then it becomes necessary to enable it to start handling requests. When the ASA receives an acceptance response from the filtering server, it forwards the response from the HTTP or FTP server to the client host. If the filtering server denies the connection or content, the response from the server is dropped, and redirects the HTTP connection to a "blocked" page, or returns "code 550: Directory not found" to an FTP client (Frahim & Santos, 2006). The commands **filter url**, **filter https**, and **filter ftp** are used to enable the ASA to use the configured filter server for URL and content filtering. The syntax for the three commands are as follows (Cisco ASA Command Reference, 2008):

```
filter url <port> [-<port>] | except <local_ip> <mask> <foreign_ip>
    <foreign_mask> [allow] [cgi-truncate] [longurl-truncate |
    longurl-deny] [proxy-block]

 filter https <port> [-<port>] | except <local_ip> <mask>
    <foreign_ip> <foreign_mask> [allow]
```

filter ftp <*port*> [-<*port*>] | **except** <*local_ip*> <*mask*> <*foreign_ip*> <*foreign_mask*> [**allow**] [**interact-block**]

There are a few pieces of note in the syntax, the following table will explain further (Frahim & Santos, 2006).

Table 2-1: Syntax of Filter Command

Syntax	Description
filter	Keyword used to enable content filtering
url	Keyword to enable HTTP filtering
port[-port]	TCP port number(s) for URL filtering. The security appliance inspects packets on this port(s). This can be either a single port or a range of ports.
local_ip	IP/subnet address of the inside hosts where the connection originated. Can use the shorthand 0 to select all hosts.
local_mask	Subnet mask of the local IP/Subnet address.
foreign_ip	IP/Subnet address of the outside servers to which the connection is made. Shorthand of 0 to select all hosts.
foreign_mask	Subnet mask of the foreign IP/Subnet address
allow	Allows the response from the content server if the filtering server is not available.

Syntax	Description
proxy-block	Denies requests going to the proxy server.
longurl-truncate	Truncates URLs that are longer than the maximum allowed length before sending the request to the filtering server
longurl-deny	Denies outbound connection if the URL's are longer than the maximum allowed length.
cgi-truncate	Truncates long CGI URLs before sending the request to the filtering server to save memory resources and improve firewall performance
https	Keyword to enable https filtering
ftp	Keyword to enable FTP filtering
interact-block	Denies interactive FTP sessions that do not provide the entire directory path.
except	Creates an exception for a previous rule.

On the SANSecure network, the enterprise would like to filter any request that is going to pass through to the Internet, but bypass filtering for all DMZ web servers. To do this, example 2-14 is used.

Example 2-14: Configuring Filtering in the SANSecure Network

```
filter url 80 0 0 0 0 allow longurl-deny cgi-truncate

filter url 80 except 0 0 172.17.0.0 255.255.0.0 allow

filter https 443 10 0 0 0 0 allow

filter ftp 20-21 0 0 0 0 allow
```

The line containing the **except** keyword allows the traffic headed for the DMZ to pass unmolested. In the event that the filtering server is unavailable, the **allow** keyword is configured so that web browsing is not stopped. This is left to the discretion of the individual organization's security policies.

Lastly, we come to content filtering. The ASA can detect, natively, ActiveX and Java applets, and render them harmless. The firewall administrator can configure certain applets as trusted, and allow those through, and drop all others, thus protecting the users from harmful or malicious code, by commenting out the <OBJECT> and <applet> tags in the HTML headers. The syntax for those is listed below; they work very similarly to the URL filtering headers above.

filter java { [*port*[**-***port*] | **except** } *local_ip local_mask foreign_ip foreign_mask*]

```
filter activex | java <port> [-<port>] | except <local_ip> <mask>
    <foreign_ip> <foreign_mask>
```

It is sound security policy to filter all unknown java and ActiveX controls, until a security administrator can approve them. Creating an exception in the filtering list will allow for known benign applets to be downloaded. Example 2-15 demonstrates ActiveX and Java filtering for the SANSecure network.

Example 2-15: ActiveX and Java Filtering on the SANSEcure network

```
filter java 80 0 0 0 0
filter activex 80 0 0 0 0
filter java 80 except 0 0 172.17.0.0 255.255.0.0
filter activex 80 except 0 0 172.17.0.0 255.255.0.0
```

Using this example, one can see that all ActiveX and Java applets from the DMZ will be allowed, but applets from the Internet will be blocked. Multiple exceptions can be added as new safe applets are discovered.

3 Intrusion Detection / Prevention

3.1 ASA and Intrusion Prevention Systems

The Cisco ASA code allows for two ways to block malicious traffic. All ASA models have a built-in rule set, and various application inspection protocols. ASA models 5510 and up, however, offer the option of installing and using a separate intrusion prevention system (IPS) blade – the AIP-SSM module. The AIP-SSM works exactly like any other Cisco network-based IPS (NIPS), with the exception that, instead of requiring that SPAN ports be configured, or a device be placed in the physical path of the network, the AIP-SSM inspects traffic on the backplane of the firewall while the traffic is still traversing it, giving faster response, and the ability to filter traffic on all networks with a single device. Since tuning the IPS is beyond the scope of this document, focus will remain on the application inspection and smaller database of signature-based rules in the standard ASA code.

3.2 Application Inspection

The ASA uses stateful packet inspection as a filtering technology, with the additional ability to employ layer-7 packet examination. The ability to reject packets that are out of state, instead of solely looking at source and destination is why one would use a firewall rather than

rely on packet filtering ACL's on a border router. Unfortunately, many older, insecure protocols from the early inception of the Internet, before the advent of stateful packet inspection firewalls, such as FTP, are still in use today. The ASA has the ability to peer into the application layer of the packet, and make appropriate dynamic changes to the ACL, to permit return traffic (Frahim & Santos, 2006). Cisco took this further when they added the concept of state to protocols that are essentially stateless – ICMP and UDMP. With ICMP inspection, an echo-reply will be connected to an outbound echo-request; with RTSP inspection, information about the TCP control channel creates the dynamic openings for the incoming streaming UDP. The following table lists the protocols that can be inspected with the ASA application inspection feature. One can clearly see that there is an expansive list of protocols on which the ASA can perform application inspection. Furthermore, each of them can be configured to inspect the legitimacy of the packets within the protocol, to help defray the possibility of malicious traffic.

Table 3-1: Supported Application List

Protocol Name	Protocol	Source Port	Destination Port
CTIQBE	TCP	Any	2748
DNS	UDP	Any	53
FTP	TCP	Any	21
GTP	UDP	2123, 3386	2123, 3386
H.323 H225	TCP	Any	1720

Protocol Name	Protocol	Source Port	Destination Port
H.323 RAS	UDP	Any	1718-1719
HTTP	TCP	Any	80
ICMP	ICMP	--	--
ILS	TCP	Any	389
MGCP	UDP	2427, 2727	2427, 2727
NetBIOS	UDP	Any	137-138
SUNRPC	UDP	Any	111
RSH	TCP	Any	514
RTSP	TCP	Any	554
SIP	TCP, UDP	Any	5060
Skinny	TCP	Any	2000
SMTP/ESMTP	TCP	Any	25
SQLNet	TCP	Any	1521
TFTP	UDP	Any	69
XDMCP	UDP	Any	177

There are three steps required to configure traffic for application inspection. The first is to create a class map, which determines the traffic that will be defined as interesting. One can choose to inspect all traffic, or limited traffic, or the default-inspection-traffic, which would be all of the traffic classes in table 3-1 on their native ports. Since most networks use the native ports for most protocols, it is considered acceptable to use the default-inspection-traffic class for the inspection.

Example 3-1: Matching Default Inspection Traffic

```
class-map inspection_default
   match default-inspection-traffic
```

Should the network administrator choose, it is possible to use **match** with an ACL, the keyword **any**, or a port number. (There are other things which can be matched, but those are only used for QoS, which is beyond the scope of this document.) Remember, this section is

only defining the traffic that the application inspection will hand over for processing; it does not enable inspection on any of the traffic at this point.

Once the class map is created, one needs to create a policy based on that class. This is the point at which the administrator tells the firewall on which packets to act. The default inspection policy includes several members of the default inspection class, but not all. One creates a policy-map, and gives it a name, calls the class defined earlier, and then proceeds to add statements regarding which protocol features to inspect.

Example 3-2: Default Inspects

```
policy-map global_policy
  class inspection_default
      inspect dns maximum-length 512
      inspect ftp
      inspect h323 h225
      inspect h323 ras
      inspect netbios
      inspect rsh
      inspect rtsp
      inspect skinny
      inspect esmtp
      inspect sqlnet
      inspect sunrpc
      inspect tftp
```

```
    inspect sip
    inspect xdmcp
```

One can see that there are a lot of protocols being inspected, which can lead to a lot of excess CPU overhead if traffic is passing on those ports, but is not actually of that protocol. Best practices dictate that traffic which will not be passing through the ASA not be on the inspect list; this prevents each packet from having to be matched against the inspection list at all. (This becomes even more important if the class-map has the **match all** option selected.) For example, the perimeter firewall, which will also serve to break away the DMZ, should never be passing NetBIOS or RSH, so those two inspects can be disabled. Ideally, TFTP will not be used anywhere, but it may need to be used to transfer configurations to and from Cisco routers and switches. Leaving that enabled is up to the discretion of the network administrator, based on the environment. Likewise, the VOIP protocols can be disabled where no VOIP is in use, further saving processor cycles, and preventing opportunity for a potential future remote exploitation of an error in the protocol parser. (While it is nice to dream that these things never happen, the fact is that new exploits are found every day. Reducing the threat profile by preventing application inspection for an application that is not being used is one way to increase security.)

Deeper packet inspection is applied to certain protocols by calling a secondary policy-map within the inspect line. For example, if a secondary policy-map for DNS named

DNS_Inspection is configured, then the line to call it from the global inspection policy is **inspect dns DNS_Inspection.** The secondary policy map is created by defining the ID, and then using the parameters statement to set the various minimums and maximums allowed by the protocol. Each one is different, and best practices will be covered on a per-protocol basis. The figure below shows the inspect engines that can be configured.

Figure 3-1: Available Deep Inspection Types

```
gateway(config)# policy-map type inspect ?

configure mode commands/options:
  dcerpc            Configure a policy-map of type DCERPC
  dns               Configure a policy-map of type DNS
  esmtp             Configure a policy-map of type ESMTP
  ftp               Configure a policy-map of type FTP
  gtp               Configure a policy-map of type GTP
  h323              Configure a policy-map of type H.323
  http              Configure a policy-map of type HTTP
  im                Configure a policy-map of type IM
  ipsec-pass-thru   Configure a policy-map of type IPSEC-PASS-THRU
  mgcp              Configure a policy-map of type MGCP
  netbios           Configure a policy-map of type NETBIOS
  radius-accounting  Configure a policy-map of type Radius Accounting
  rtsp              Configure a policy-map of type RTSP
  sip               Configure a policy-map of type SIP
  skinny            Configure a policy-map of type Skinny
```

One inspection that is turned on by default is DNS inspection. It helps to prevent spoofing of DNS replies by ensuring that each DNS reply matches the ID of a DNS request, and helps prevent buffer overflow attacks by reassembling DNS packets to ensure that the length is below a prescribed maximum. Best practices state that it's best to expand that to 1,024 bytes, as there are several applications that use larger responses than 512 bytes (Frahim and Santos, 2006). Newer versions allow ID randomization, which is described in CERT Vulnerability Note VU#800113 (CERT, 2008). Example 3-3 demonstrates the command sequence to secure DNS replies.

Example 3-3:

```
policy-map type inspect dns DNS_Secure
 parameters
  message-length maximum 1024
  id-randomization
  id-mismatch count 10 duration 5 action log
policy-map global_policy
 class inspection_default
  !
<output omitted>
  !
  inspect dns DNS_Secure
```

The next default inspection that is recommended for all sites is ESMTP inspection. This "protects against SMTP-based attacks by restricting the types of SMTP commands that can pass through the Cisco ASA" (Frahim and Santos, 2006). The inspection allows the following commands:

- AUTH
- DATA
- EHLO
- ETRN
- HELO
- HELP
- MAIL
- NOOP
- QUIT
- RCPT
- RSET
- SAML
- SEND
- SOML

- VRFY

When faced with a command that is not allowed by the inspection, the firewall modifies the SMTP packet and forwards it, causing the server to respond with a “500 (command not recognized)” response, and tears down the connection.

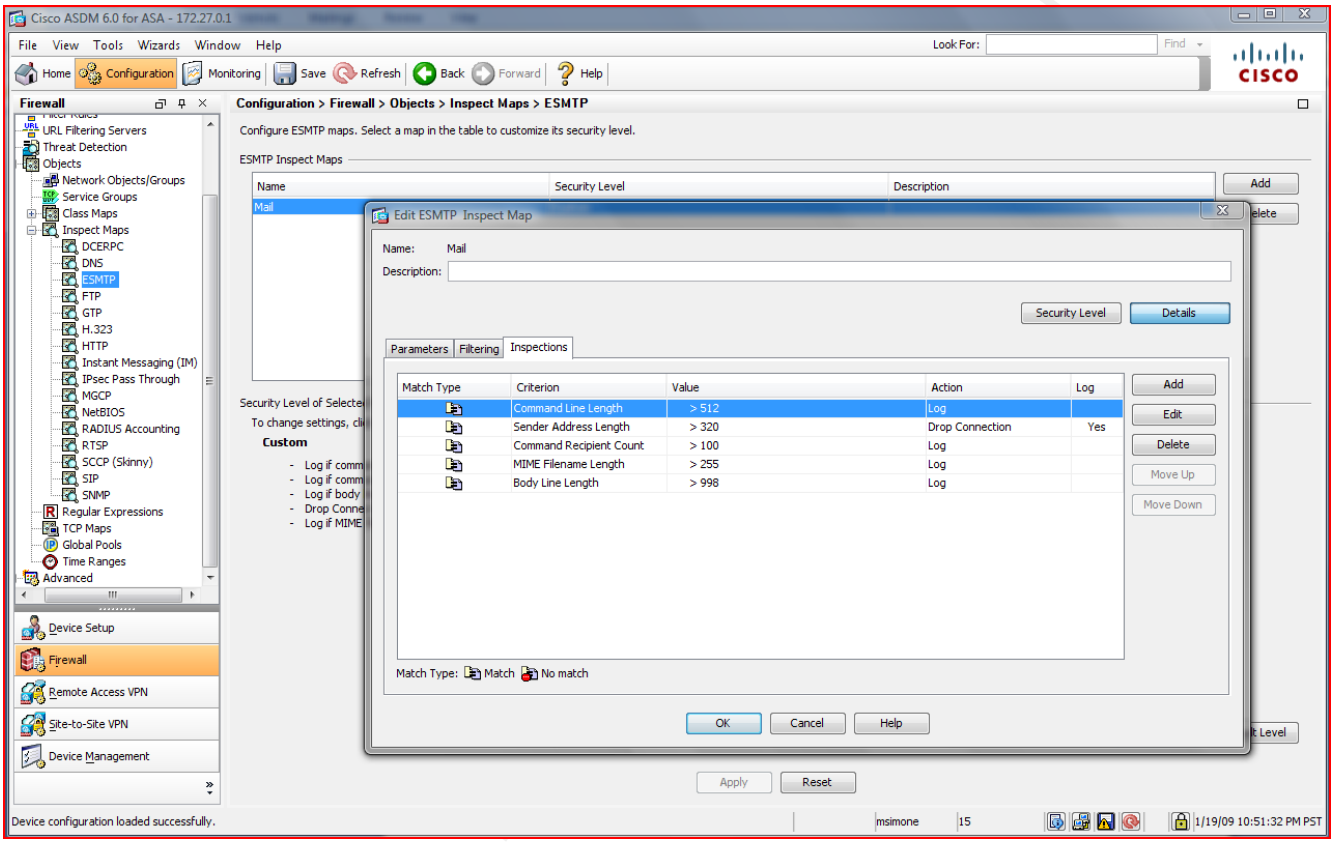
Accepted commands can be subjected to even deeper packet inspection, with an **inspect type** class. For example, if one is using a Microsoft Exchange server, then it becomes important that the ASA not obscure the SMTP banner, or else it cannot properly send and receive email. To create a deep inspection type, one would follow example 3-4. By default, the ASA will block email to and from an Exchange server, one must enable the deep packet inspection of ESMTP traffic, or mail will break.

Example 3-4: Deeper SMTP Inspection

```
policy-map type inspect esmtp Mail
 parameters
  no mask-banner
  special-character action drop-connection log
 match MIME filename length gt 255
  drop-connection log
 match cmd line length gt 512
  drop-connection log
 match cmd RCPT count gt 100
  drop-connection log
 match body line length gt 998
  drop-connection log
 match sender-address length gt 320
  drop-connection log
match cmd verb VRFY
  mask log
```

This, of course, is simply an example, as there are hundreds of options available for SMTP inspection. For this, it is really recommended that one use the ASDM to configure the SMTP inspection, as the menus make it far easier to see what is available. To access this in ASDM, select Configuration, then Firewall, then expand Inspect Maps, and select ESMTP, as shown in Figure 3-2.

Figure 3-2: Inspect Maps in ASDM



Example 3-4 inspects incoming SMTP traffic, and performs the following actions:

- Unmasks the banner (to allow MS Exchange to work properly)
- Drops the connection and generates a log if
  - any special characters appear in the commands
  - any MIME filename of greater length than 255 characters attempts to pass

  - any command line is greater than 512 characters
  - the recipient count on the email is greater than 100 users
  - the body line length is greater than 998 characters
  - the sender address is greater than 320 characters

- Masks the command (resulting in a 500 error) for any attempts to run the VRFY command.

These commands increase the security of inbound email by preventing many malicious SMTP tricks from traversing the firewall, and by preventing data leakage with the VRFY command. (The VRFY command confirms the existence and full name of a user on the box, which could later be used in a social engineering attack (RAD University, 2008).)

Continuing through the list of default inspections, we next encounter FTP. While, in a truly secure world, FTP would not be used at all, it is still prevalent in many enterprises to this day, and FTP inspection needs to be enabled. Not only will it match the control and data connections as established connections, but it can perform deep packet inspection. One difference in calling the deep inspection map is that there is the opportunity to request strict FTP inspection, using the line **inspect ftp strict** *ftp-map-name*. The **strict** modifier is optional. If

enabled, however, the connection must adhere to the exact requirements of the RFC, otherwise the connection will be reset. The ftp-map will deny requests to perform certain actions during an FTP connection. Figure 3-3 lists the available commands and what they do (Frahim & Santos, 2006).

Figure 3-3

Option	Description
All	Denies all supported FTP commands
appe	Denies the ability to append to a file
cdup	Denies a user request to change to parent of current directory
help	Restricts the user to access the help information from the FTP server
get	User is not allowed to retrieve files
mkd	User is not allowed to create directories
put	User is not allowed to upload files
retr	Denies the retrieval of a file from the FTP server
rnfr	User is not allowed to rename from a filename
rnto	User is not allowed to rename to a specific filename
site	User is not allowed to specify a server-specific command
stor	Denies the user permission to store a file

Option	Description
stou	Denies the user permission to store a file with a unique name

Further options in an FTP inspect map include file type filtering based off of a regex string, masking of banners, and masking replies to the SYST command. At the very least, a secure site should be masking the banners. Example 3-5 shows the commands required to make this effective.

Example 3-5

```
policy-map type inspect ftp FTP_Secure
 parameters
  mask-banner
  mask-syst-reply
 match request-command rnfr rnto site
  reset log
policy-map global_policy
 class inspection_default
  inspect ftp strict FTP_Secure
```

These inspections are enabled by default. The other default inspections, as stated earlier, can be turned on or off or tuned to the requirements of the local security policy, and no best practices document can adequately address the myriad configuration issues involved

with all of them. However, there are two inspections that are not enabled by default; one should use the HTTP and ICMP inspections.

ICMP inspection has only one option: whether or not to inspect ICMP error messages. Simply turning on ICMP inspection will allow for matching echo requests with replies. Turning on error inspection causes the ASA to inspect the data portion of the error message and ensure that it is present and correct. Without having ICMP inspection turned on, PING testing through the ASA will fail, causing frustration to the network administrator who is trying to diagnose network issues.

HTTP inspection, like SMTP and FTP, contains dozens of options; it is recommended that the basic outline of HTTP inspection be completed in ASDM. The ASDM comes with a large number of tunneled IM, P2P, and tunneled remote access protocols. It is recommended that, at the very least, the defaults are all disabled, as are potentially unsafe methods. The best way to do this is through the ASDM.

1. Click on Service Policy Rules
2. Select the service policy that will contain the HTTP inspection (usually the inspection_default)
3. Select Rule Actions

4. Check HTTP, and click Configure
5. Click Select an HTTP map
6. Click Add to create a new Inspect Map.
7. Change the security level to Medium. This will cause the following actions:
    a. Drop connections with protocol violations
    b. Drop connections for unsafe methods, only allowing GET, HEAD and POST
8. Select Details
9. Select Inspections
10. Click Add
11. Select Request Method as the criterion
12. Click Regular Expression Class and click Manage
13. Click Add
14. Give it a useful name, like “All_Tunneled_Traffic”
15. Select all the regex defaults and click Add
16. Click OK three times. We select drop because reset causes a TCP reset to be sent, which frees up the resource on the violating machine too quickly. Using drop causes it to wait until it times out.
17. Click add again.
18. Select Request Body as the Criterion.

19. Select Regular Expression class, and find All_Tunneled_Traffic in the drop-down list
20. Click OK twice.
21. Click Apply

This will protect against some dangerous methods, and also block instant messenger traffic being tunneled over HTTP. One can work with one's MSSP to help develop regex signatures for even more classes of tunneled traffic, and add them to the inspection class as one learns of them. For those who wish not to use the ASDM, the commands that match the above are shown in example 3-6.

Example 3-6

```
class-map type regex match-any All_Tunneled_Traffic
 description All IM, P2P and Remote Access tunneled over HTTP
 match regex _default_aim-messenger
 match regex _default_yahoo-messenger
 match regex _default_GoToMyPC-tunnel
 match regex _default_gator
 match regex _default_firethru-tunnel_2
 match regex _default_firethru-tunnel_1
 match regex _default_msn-messenger
 match regex _default_x-kazaa-network
 match regex _default_GoToMyPC-tunnel_2
 match regex _default_icy-metadata
 match regex _default_gnu-http-tunnel_uri
 match regex _default_httport-tunnel
```

```
 match regex _default_windows-media-player-tunnel
 match regex _default_gnu-http-tunnel_arg
 match regex _default_http-tunnel
 match regex _default_shoutcast-tunneling-protocol
class-map type inspect http match-all asdm_medium_security_methods
 match not request method head
 match not request method post
 match not request method get
policy-map type inspect http SecureHTTP
 parameters
  protocol-violation action drop-connection
 match request body regex class All_Tunneled_Traffic
  drop-connection log
 match request method regex class All_Tunneled_Traffic
  drop-connection log
policy-map global_policy
 class inspection_default
  inspect http SecureHTTP
```

Obviously, before enabling this globally, it is good to check with the business units to determine if some of these commands or protocols are allowed and necessary.

The last phase of implementing application inspection is determining whether to have it inspect on a global or an interface level. Since it is good to have these protocols inspected whenever they traverse the firewall, enabling globally is a good plan, but there will be times when an interface may need some extra attention. In that case, one would create a new class

map, a new policy map, and apply that service policy to only the selected interface. To enable the default_inspection_policy globally, use the command **service-policy default_inspection_policy global**. To enable a policy called DMZ_policy on the DMZ interface, one would issue the **service-policy DMZ_policy interface dmz.** This activates the service policy, and begins the protocol inspection on the device.

3.3 Signature-based IPS

Application inspection can only offer a certain level of protection. Many attacks that propagate through the network do not violate protocols, or use unsafe methods; they simply exploit a weakness in the programming of an application or service. While monitoring logs has its uses, there are instances when the delay between the time of an attack and the time that an analyst can detect the attack means that the damage is already done. This is why Cisco implemented their intrusion detection system (IDS) and intrusion prevention system (IPS) into the Cisco ASA.

Cisco has certain standards for their IDS/IPS devices. As Kaeo states,

> [A] good intrusion system should have the following characteristics
>
> - It must run continuously without human supervision. The system must be reliable enough to allow it to run in the background of the system being observed.
> - It must be fault tolerant in the sense that it must survive a system crash

and not require its knowledge base to be rebuilt at restart.

- It must resist subversion. The system can monitor itself to ensure that it has not been subverted.
- It must impose minimal overhead on the system. A system that slows a computer to a crawl will simply not be used.
- It must observe deviations from normal behavior and immediately alert someone to the event of abnormal behavior.
- It must cope with changing system behavior over time as new applications are being added.

All of these requirements are fully met with the **ip audit** feature native to the Cisco ASA code. It is a signature-based IPS, with capability to drop packets, or shun hosts; the signatures are built into the ASA code and don't need to be re-learned; unless the firewall is completely compromised, the system cannot be subverted; and the overhead is small. This meets or exceeds all of Cisco's requirements for an IDS/IPS system.

The ASA, in version 8.0(4), contains 51 signatures for different network based threats. Leaving all of them enabled can lead to overload of the analysts' event queue, disabling too many of them can lead to missed attacks. As with all IPS tuning, there remains a great deal of art to the science of maintaining the balance. The signatures are broken into two different categories: informational and attack. Informational signatures detect reconnaissance, such as ping sweeps; attack signatures look for actual threats, such as Ping of Death (Owe, 2008). The complete signature list is included in Appendix A, for completeness.

The first thing to consider is which signatures to disable, if any. If one is going to

establish a strict IP audit policy, then one must disable three signatures – 2000, ICMP Echo-Reply, 2001, ICMP Echo-Request, and 2004, ICMP Unreachable. If these signatures are disabled, it is imperative that one use the ICMP inspection from the previous section, to prevent against attacks by tools such as Loki (Cole, 2002). Best practices dictate that all other signatures remain enforced, unless there is a documented business need for that traffic to pass. Example 3-7 demonstrates disabling these three signatures.

Example 3-7: Disabling Echo Request, Echo Reply, and ICMP Unreachable Signatures

```
ip audit signature 2000 disable
ip audit signature 2001 disable
ip audit signature 2004 disable
```

When configuring the **ip audit** function, one can select one or more of three options for response to the presence of a packet matching an enabled signature – alarm, which sends an alert to the logging server and management console, or drop, which will delete the packet without sending it on to the destination host, or reset, which sends a TCP RST packet to both ends of the connection. Since most of the informational signatures can indicate an attacker trying to bypass routing or IDS, it is best to tune them to drop and alert, while the attacks should alert, drop and reset.

To configure the IP Audit function, one must first create two profiles, one for attack

packets, and one for informational packets. These use the **ip audit name** command. The syntax for this command is

ip audit name *audit_name* {**info**|**attack**} [**action** [**alarm**] [**drop**] [**reset**]]

Example 3-8 demonstrates configuring the Attacker and Snooper ip audit profiles. It is prudent to have differing levels of response, based on whether the attacker is inside or outside.

Example 3-8: Configuring IP Audit Profiles

```
ip audit name Snooper info action alarm drop
ip audit name Attacker attack action alarm drop reset
ip audit name Internal_Info info action alarm
ip audit name Internal_Malicious attack action alarm drop
```

Finally, one must apply the profile to an interface. The more stringent profiles should be applied to the outside interface, with a more lenient one on the inside, as demonstrated in Example 3-9.

Example 3-9: Applying profiles to Interfaces

```
ip audit interface inside Internal_Info
ip audit interface inside Internal_Malicious
ip audit interface dmz Internal_Info
ip audit interface dmz Internal_Malicious
ip audit interface outside Snooper
ip audit interface outside Attacker
```

This allows an enterprise network to extend the capabilities of the firewall to protect against some known, common threats. Obviously, this is not a comprehensive list of signatures; in order to have the most up-to-date signature list and tuning, one must install the AIP-SSM blade, and regularly download signatures. Also, it is important to have constant review of the logs, to determine if there are compromises within one's network; for that, it is recommended that the enterprise secure the services of an MSSP with log analysis services.

4 Virtual Private Networking

One of the most powerful features of the Cisco ASA device is its ability to maintain site-to-site and remote access VPN tunnels. The advantages of having the VPNs terminate on the firewall include:

- Reduced number of hardware devices in the datacenter
- Reduced cost of licensing
- Failover capability
- Better security, as traffic is decrypted and then examined by the ASA. This prevents decryption outside of the firewall, where traffic must pass in clear text before being examined, and it prevents malicious traffic from passing through the firewall encrypted to an internal VPN concentrator.
- Ability to use client-based or clientless VPNs.

This does not mean that it is without disadvantages. Using the firewall as a VPN termination device does require more processing power and memory, and it sometimes requires a special license; this may make one select a more powerful (and therefore expensive) model than initial estimates would have suggested.

The details of how encryption methods work is beyond the scope of this document. For an excellent treatment on encryption protocols, public and shared key security, and hashing algorithms consult *Designing Network Security*, listed in the bibliography.

Authentication of the remote peer is the first important consideration for a VPN. For an L2L VPN, one can use IP address or a certificate, for RA, a group name provides the identity. The certificate method is considerably more scalable, especially for RA VPN's, as there's no need to adjust the pre-shared key in the event that an employee leaves. The downside of the public-key infrastructure (PKI) is that the enrollment and certificate revocation list servers must be reachable from outside of the network, and require considerable time and effort to configure. If one wishes to use globally recognized root certificate authorities, then services must be contracted through a vendor like Verisign or Baltimore UniCERT. Once they are up, and reachable, the ASA can be configured to use them to obtain its certificate, and use that to authenticate itself during phase 1 negotiations.

Assuming that there is a PKI in place, the first step is to generate the RSA key that will be used on the device. Since that should have been completed in part two above, it's a simple matter of entering the **show crypto key mypubkey rsa**. This will display the default RSA key that was generated on the device.

The next step is to configure a trustpoint. A trustpoint is the server from which

enrollment will take place; all of the necessary certificate parameters will be configured here. Table 4-1 lists the available parameters for the trustpoint command (Frahim & Santos, 2006).

Example 4-1

Subcommand	Description
accept-subordinates	Allows the Cisco ASA to accept subordinate CA certificates
crl	CRL options
default	Returns enrollment parameters to their default parameters
email	Used to enter the email address to be used in the enrollment request
enrollment	Enrollment parameters; • **retry –** Polling retry count and period. • **self** – Enrollment will generate a self-signed certificate • **terminal** – Used for manual enrollment (cut-and-paste method) • **url** – the URL of the CA server
fqdn	Includes fully qualified domain name
id-cert-issuer	Accepts ID certificates
ip-address	Includes IP address
keypair	Specifies the key pair whose public key is to be certified
password	Returns password
serial-number	Includes serial number

Subcommand	Description
subject-name	Subject name
support_user_cert_validation	Validates remote user certificates using the configuration from this trustpoint, provided that this trustpoint is authenticated to the CA that issued the remote certificate.

Example 4-1 demonstrates configuring an internal domain controller running Microsoft Certificate Services.

Example 4-2: Configuring a Trustpoint

```
SANSecureASA(config)# crypto ca trustpoint CISCO
SANSecureASA(ca-trustpoint)# enrollment url http://10.0.1.2/certsrv/mscep/mscep.dll
SANSecureASA(ca-trustpoint)# enrollment retry count 3
SANSecureASA(ca-trustpoint)# enrollment retry period 5
SANSecureASA(ca-trustpoint)# fqdn SANSecureASA.sansecure.fake
SANSecureASA(ca-trustpoint)# exit
```

Once the trustpoint is configured, then one simply runs the command **crypto ca enroll CISCO**, to cause it to pull the certificate from the trustpoint. (Obviously, if the trustpoint requires authentication, then the earlier example would need to include a subject name and a password.)

Once a certificate is enabled on the device, one should allow for the possibility that

some VPNs may connect using pre-shared keys, and others will connect using their certificates. To enable this, one uses the command **isakmp identity auto**. This will allow the ASA to determine by the request of the peer which method of authentication to use.

Pre-shared keys, on the other hand, are fairly easy and straightforward to configure on the ASA. One creates a tunnel-group for each remote peer, and configures the attributes, as demonstrated in example 4-2. SANSecure is creating a pre-shared key partnership with a host at IP address 1.2.3.4. In this example, ISAKMP dead peer detection will send a keepalive packet after 30 seconds of inactivity, and send 5 packets until the peer responds, or it will consider the tunnel dead.

Example 4-3: Configuring a Tunnel-Group for L2L VPN

```
SANSecureASA(config)# tunnel-group 1.2.3.4 type ipsec-l2l
SANSecureASA(config)# tunnel-group 1.2.3.4 ipsec-attributes
SANSecureASA(config-ipsec)# pre-shared-key 500p3r533kr3t@54N5!
SANSecureASA(config-ipsec)# isakmp keepalive threshold 30 retry 5
```

This creates a partnership agreement between the two VPN peers.

The next step is to define the ISAKMP phase 1 policies. Each policy has a priority number, the lower the number, the earlier in the list one will encounter it. The highest security policies should have the lowest ID number, to ensure that they are selected first, where available. There are five available attributes: authentication type, encryption, Diffie-Hellman

group, hash, and lifetime. Every attribute on both sides must match. While all five attributes do not need to be defined explicitly, as the ASA will substitute the default value, the defaults may not always be the most secure choice. Example 4-4 demonstrates the ISAKMP policies enabled on the SANSecure perimeter ASA.

Example 4-4: SANSecure Phase 1 Policies

```
isakmp policy 5 authentication rsa-sig
isakmp policy 5 encryption aes-256
isakmp policy 5 group 5
isakmp policy 5 hash sha
isakmp policy 5 lifetime 86400

isakmp policy 6 authentication rsa-sig
isakmp policy 6 encryption 3des
isakmp policy 6 group 2
isakmp policy 6 hash sha
isakmp policy 6 lifetime 86400

isakmp policy 15 authentication pre-share
isakmp policy 15 encryption aes-256
isakmp policy 15 group 5
isakmp policy 15 hash sha
isakmp policy 15 lifetime 86400

isakmp policy 16 authentication pre-share
isakmp policy 16 encryption 3des
```

```
isakmp policy 16 group 2
isakmp policy 16 hash sha
isakmp policy 16 lifetime 86400

isakmp enable outside
```

This example demonstrates preferring public key authentication to pre-shared keys, and preferring aes-256 encryption to 3des. The lower security quintet of each authentication type is to support older devices which may not be able to cope with AES or DH group 5. Notice that there is room in between to put in different hashing values or Diffie-Hellman groups. The best practices rule of thumb is to keep the highest security levels nearest the top of the list, so that they are used.

Once phase one negotiation is complete, it is time to configure the phase two encryption parameters. This is done by creating a transform-set, which is very similar to the phase one parameters. The syntax for creating a transform set is

crypto ipsec transform-set *transform-set-name* { **esp-3des | esp-aes | esp-aes-192 | esp-aes-256 | esp-des } {esp-md5-hmac | esp-null | esp-sha-hmac}**

There are three parts to the transform set. The transform set name, the encryption algorithm, and the hashing algorithm. Obviously, since this is the data portion of the encryption, security

is just as important as the key exchange, but processor load comes into consideration here. If at all possible, it is best to use AES-256 and SHA-1 as the hashing algorithm, as there have been recent collisions detected in MD5 (Stevens et. al., 2008). Example 4-5 demonstrates the transform sets enabled on the SANSecure ASA.

Example 4-5: Transform Sets on SANSecureASA

```
crypto ipsec transform-set ESP-A256-SHA esp-aes-256 esp-sha-hmac

crypto ipsec transform-set ESP-3DES-SHA esp-3des esp-sha-hmac
```

The next step is to identify interesting traffic. Interesting traffic is defined as traffic that should pass through the VPN tunnel. This is not the place to define access control lists to determine which ports and protocols are allowed, as many VPN devices do not understand port based ACLs. This step solely identifies the networks that can communicate with one another through the tunnel. One major caveat to keep in mind is that, when configuring a VPN with a non-Cisco device, this can be the tricky part. For example, when connecting to a Check Point, one must select the “support key exchange for subnets” in the Check Point GUI, or else the way the ASA parses the access list will cause phase 2 to drop. In the SANSecure example, users on subnet 10.0.50.0/24 are allowed to connect via the VPN to a business partner named ParterCorp, whose internal network is 172.31.24.0/24.

Example 4-6: Defining Interesting Traffic

```
access-list PartnerCorp permit ip 10.0.50.0 255.255.255.0 172.31.24.0 255.255.255.0
```

Note that this defines all traffic from both of those subnets as interesting. This sounds potentially insecure, but it is not – the filtering has yet to take place.

If both sides of the connection are going to define filtering based off of the actual IP addresses of the devices, it is important to ensure that no NAT takes place from one network to the other. In this case, one creates a NoNAT access list, and applies it with the **nat 0** command, as shown in example 4-7.

Example 4-7: NoNAT Access List

```
access-list NoNAT permit ip 10.0.50.0 255.255.255.0 172.31.24.0 255.255.255.0

nat (inside) 0 access-list NoNAT
```

Note that no matter how many connections to other companies an enterprise has, while there will be a separate ACL to determine interesting traffic to for that tunnel, there will only ever be one NoNAT ACL, to which each network pair must be added.

The penultimate stage of creating an L2L VPN is creating the crypto map statement. There can be only one crypto map applied to an interface, so each separate VPN connection

requires its own ID number. Each map ID must contain at least one transform set, at least one VPN peer, and a crypto ACL. If one is running dynamic routing protocols on the ASA, one may use reverse route injection to propagate to the network the location of this new network, if the default routing will not take it there. The syntax for this is **crypto map** *map-name seq-num* **set reverse-route.** This will become listed as a static route, so it is important to redistribute that into the routing protocol with the command **redistribute static subnets.** Another important step is configuring perfect forward secrecy, if the remote site will support it. PFS causes new keys to be generated that are unrelated to the old keys, requiring a new DH exchange, so that one broken key cannot lead to continuing compromise of the encrypted tunnel. Building on the example of the SANSecure network to PartnerCorp, example 4-8 demonstrates how this operates.

Example 4-8: Configruring a Crypto Map

```
crypto map vpnmap 1 set transform-set ESP-A256-SHA

crypto map vpnmap 1 set peer 1.2.3.4

crypto map vpnmap 1 set pfs group5

crypto map vpnmap 1 match address PartnerCorp

crypto map vpnmap 1 set reverse-route
```

```
crypto map vpnmap interface outside
```

Those statements will cause a VPN tunnel to come up once interesting traffic attempts to traverse the network (assuming, of course, that the mirror image of the VPN is enabled on the remote side (Morgan and Lovering, 2008). Finally, one must decide which traffic to filter. Cisco allows the option of permitting any tunneled traffic through the firewall using the **sysopt connect permit-ipsec** command, but that, then, defeats the purpose of using the ASA as a VPN termination point. Instead, one needs to modify the access list of the interface on which the VPN terminates. Usually, this is the outside interface. Here is where one would enable the ports and protocols that one wishes to see traversing the network. For example, if SANSecure only wanted HTTP and HTTPS traffic to come through from PartnerCorp, the following lines would be added to the appropriate part of the outside_access_in access-list on the outside interface.

Example 4-9: Filtering VPN Traffic

```
object-group service VPNHTTP
    port eq 80
    port eq 443
access-list outside_access_in extended line 5 permit 172.31.24.0 255.255.255.0 host
  10.0.50.2 object-group VPNHTTP
```

All traffic that does not match the access-list, or that hits an explicit deny earlier in the ACL, will be dropped, providing security to the network. Conversely, outbound filtering is handled by the egress filter already in place on the appropriate interface.

Remote access VPNS are very similar to L2L VPNs. One can continue to use the same ISAKMP policies, and the same transform sets. The difference is in the authentication and user policies.

There are three places where a user's policies may be enabled – default group-policy, user group-policy, and user policy. This is a hierarchical policy structure, which means that anything from the default flows to the user groups, which flow to the users. Therefore, the more general policies apply to the default properties, and the most specific apply to a single user. The group attributes that can be set are listed in Table 4-1.

Table 4-1: Group Policy Subcommands

Subcommand	Attribute
address-pools	Configure list of up to 6 address pools to assign addresses from
backup-servers	Configure list of backup servers to be usedby the remote client

Subcommand	Attribute
banner	Configure a banner, or welcome text to be displayed on the VPN remote client
client-access-rule	Specify rules permitting/denying access to specific client types and versions
client-firewall	Configure the firewall requirements for users in this group policy
default-domain	Configure the default domain name given to users of this group
dhcp-network-scope	Specify the range of IP addresses to indicate to the DHCP server for address assignment
dns-server	Configure the primary and secondary DNS servers
group-lock	Enter the name of an existing tunnel-group that users are required to connect with
intercept-dhcp	Enable this command to use group policy for clients requesting Microsoft DHCP
ip-comp	Enter this command to enable IP compression (LZS)
ip-phone-bypass	Configure to allow Ciscco IP phones behind hardware clients to bypass the Individual User Authentication process
ipsec-udp	Enter this command to allow a client to operate through a NAT device using UDP encapsulation
ipsec-udp-port	Enter the UDP port to be used by the client for IPSec through NAT

Subcommand	Attribute
ipv6-address-pools	Configure list of up to 6 ipv6 address pools to assign addresses from
ipv6-vpn-filter	Enter name of a configured IPv6 ACL to apply to users
leap-bypass	Enable/disable LEAP packets from Cisco wireless devices to bypass the individual user authentication process. This setting applies only to HW clients
msie-proxy	Enter this command to configure MSIE Browser Proxy settings for a client system
nac-settings	Configure the name of the nac-policy
nem	Configure hardware clients to use network extension mode. This setting applies only to HW clients.
password-storage	Enable/disable storage of the login password on the client system
pfs	Enter this command to indicate that the remote client needs to perform PFS.
re-xauth	Enter this command to enable reauthentication of user on IKE rekey.
secure-unit-authentication	Configure interactive authentication. This setting applies only to HW clients
smartcard-removal-disconnect	Configure client action for smart card removal
split-dns	Configure list of domains to be resolved through the split tunnel

Subcommand	Attribute
split-tunnel-network-list	Configure the name of access-list for split tunnel configuration
split-tunnel-policy	Select split tunneling method to be used by the remote client
user-authentication	Configure individual user authentication. This setting applies only to HW clients
user-authentication-idle-timeout	Configure the idle timeout period in minutes. If there is no communication in this period, the system terminates the connection. This setting applies only to HW clients.
vlan	Specify the VLAN onto which VPN traffic for this group will be forwarded
vpn-access-hours	Enter the name of a configured time-range policy
vpn-filter	Enter name of a configured ACL to apply to users
vpn-idle-timeout	Enter idle timeout period in minutes, enter none to disable
vpn-session-timeout	Enter maximum user connection time in minutes, enter none for unlimited time.
vpn-simultaneous-logins	Enter the number of simultaneous logins allowed
vpn-tunnel-protocol	Enter permitted tunneling protocols
webvpn	Configure group policy for WebVPN
wins-server	Configure the primary and secondary WINS servers

While most of these settings will be dictated by the topology of the network, the most important best practice to which to adhere is disabling split-tunneling. This forces all user traffic to pass through the ASA, allowing the organization to dictate content and URL filtering, enables application inspection, and enables firewall rules to be enacted on the passing traffic.

To edit the default group policy, one enters the command **group-policy DfltGrpPolicy attributes**. This leads to where each of the subcommands listed in Table 4-1 to be entered. At SANSecure, all of the remote access users share the majority of the configuration, so most of this is configured in the following example.

Example 4-10: Default Group Policy Attributes

```
ip local pool VPNPool 172.28.1.0 mask 255.255.255.0
group-policy DfltGrpPolicy attributes
vpn-simultaneous-logins 3
ip-comp enable
split-tunnel-policy tunnelall
address-pools value VPNPool
default-domain sansecure.fake
client-firewall req
dns-server 10.0.1.24
```

```
ipsec-udp
ipsec-udp-port 4500
```

The next step is to determine user groups. An internal group means that all attributes are stored on the local ASA, an external group means that all attributes are stored on an external authentication server, like a RADIUS or TACACS+ server. For individual, local users, such as the ones defined in section two, one uses the **user** *username* **attributes**, and sets the user attributes, such as their **vpn-group-policy, vpn-framed-ip-address** and **vpn-filter,** allowing for individual users to have their own specified IP address and ACL, while inheriting properties from the group.

The following step is to define the tunnel type, just as demonstrated in the L2L VPN. This time, however, the type will be set to **ipsec-ra.** Configure the tunnel group IPSec attributes just like with the L2L VPN. User authentication, however, comes from the **general-attributes** submode of the **tunnel-group** command. The authentication server is specified there, as demonstrated in the example below.

Example 4-11: Configuring Phase 1

```
SANSecureASA(config)# tunnel-group RAVPN type ipsec-ra
SANSecureASA(config)# tunnel-group RAVPN ipsec-attributes
SANSecureASA(config-ipsec)# pre-share key Uc@n7gu355m3
```

```
SANSecureASA(config-ipsec)# exit
SANSecureASA(config)# username msimonevpn password l1k31dt3llu
SANSecureASA(config)# username msimone attributes
SANSecureASA(config-username)# vpn-framed-ip-address 192.168.50.1 255.255.255.255
SANSecureASA(config-username)# vpn-filter value 102
SANSecureASA(config-username)# exit
SANSecureASA(config)# tunnel-group RAVPN general-attributes
SANSecureASA(config-group-policy)# authentication-server-group LOCAL
```

This will allow phase one to complete.

For phase two, many of the same steps are needed for an RA VPN as there were for an L2L VPN. One can use the same transform-sets that were created earlier. The main difference lies in creating a dynamic map to connect the RAVPN users. This is achieved with the command **crypto dynamic-map** *mapname seq-num attribute.* This dynamic map gets appended to the tail end of the crypto map that is already present on the outside interface from the PartnerCorp L2L VPN. Continuing on from the earlier crypto map for our L2L VPN, example 4-12 shows this configuration, in which SANSecure configures a dynamic map, allows for ISAKMP NAT traversal, and appends the dynamic map to the existing crypto map.

Example 4-12: Dynamic Crypto Map

```
crypto dynamic-map dynmap 10 set transform-set ESP-A256-SHA
crypto dynamic-map dynmap 10 set reverse-route
crypto dynamic-map dynmap 10 set pfs group5
crypto map vpnmap 65535 ipsec-isakmp dynamic dynmap
```

Once the VPN clients are configured, the users should be able to log on and use network resources according to the configured access-control lists.

5 Conclusions

The Cisco ASA demonstrates itself to be a powerful, robust network security engine, capable of protecting the network with filtering, intrusion prevention, and encryption. By combining into a single box, network administrators are capable of delivering more service for less money; the failover capability of the ASA allows for redundancy of all of these services to enable high availability, the compact nature of the device uses less rack space and small power consumption, and the ease of integration for those already running Cisco networking gear makes it a low total-cost-of-ownership solution for today's networked world. As a perimeter device, it achieves all of the security goals of the border, without onerous configuration or need for multiple administrators. The Cisco ASA is defense-in-depth in a single box.

6 Appendix A: Cisco ASA IP Audit Signature List

Source: Cisco ADSM User Guide, by Mary Owe, 2008.

Signature ID	Message Number	Signature Title	Signature Type	Description
1000	400000	IP options-Bad Option List	Informational	Triggers on receipt of an IP datagram where the list of IP options in the IP datagram header is incomplete or malformed. The IP options list contains one or more options that perform various network management or debugging tasks.
1001	400001	IP options-Record Packet Route	Informational	Triggers on receipt of an IP datagram where the IP option list for the datagram includes option 7 (Record Packet Route).
1002	400002	IP options-Timestamp	Informational	Triggers on receipt of an IP datagram where the IP option list for the datagram includes option 4 (Timestamp).
1003	400003	IP options-Security	Informational	Triggers on receipt of an IP datagram where the IP option list for the datagram includes option 2 (Security options).
1004	400004	IP options-Loose Source Route	Informational	Triggers on receipt of an IP datagram where the IP option list for the datagram includes option 3 (Loose Source Route).
1005	400005	IP options-SATNET ID	Informational	Triggers on receipt of an IP datagram where the IP option list for the datagram includes option 8 (SATNET stream identifier).

Signature ID	Message Number	Signature Title	Signature Type	Description
1006	400006	IP options-Strict Source Route	Informational	Triggers on receipt of an IP datagram in which the IP option list for the datagram includes option 2 (Strict Source Routing).
1100	400007	IP Fragment Attack	Attack	Triggers when any IP datagram is received with an offset value less than 5 but greater than 0 indicated in the offset field.
1102	400008	IP Impossible Packet	Attack	Triggers when an IP packet arrives with source equal to destination address. This signature will catch the so-called Land Attack.
1103	400009	IP Overlapping Fragments (Teardrop)	Attack	Triggers when two fragments contained within the same IP datagram have offsets that indicate that they share positioning within the datagram. This could mean that fragment A is being completely overwritten by fragment B, or that fragment A is partially being overwritten by fragment B. Some operating systems do not properly handle fragments that overlap in this manner and may throw exceptions or behave in other undesirable ways upon receipt of overlapping fragments, which is how the Teardrop attack works to create a DoS.
2000	400010	ICMP Echo Reply	Informational	Triggers when a IP datagram is received with the protocol field of the IP header set to 1 (ICMP) and the type field in the ICMP header set to 0 (Echo Reply).
2001	400011	ICMP Host Unreachable	Informational	Triggers when an IP datagram is received with the protocol field of the IP header set to 1 (ICMP) and the type field in the ICMP header set to 3 (Host Unreachable).

Signature ID	Message Number	Signature Title	Signature Type	Description
2002	400012	ICMP Source Quench	Informational	Triggers when an IP datagram is received with the protocol field of the IP header set to 1 (ICMP) and the type field in the ICMP header set to 4 (Source Quench).
2003	400013	ICMP Redirect	Informational	Triggers when a IP datagram is received with the protocol field of the IP header set to 1 (ICMP) and the type field in the ICMP header set to 5 (Redirect).
2004	400014	ICMP Echo Request	Informational	Triggers when a IP datagram is received with the protocol field of the IP header set to 1 (ICMP) and the type field in the ICMP header set to 8 (Echo Request).
2005	400015	ICMP Time Exceeded for a Datagram	Informational	Triggers when a IP datagram is received with the protocol field of the IP header set to 1 (ICMP) and the type field in the ICMP header set to 11(Time Exceeded for a Datagram).
2006	400016	ICMP Parameter Problem on Datagram	Informational	Triggers when a IP datagram is received with the protocol field of the IP header set to 1 (ICMP) and the type field in the ICMP header set to 12 (Parameter Problem on Datagram).
2007	400017	ICMP Timestamp Request	Informational	Triggers when a IP datagram is received with the protocol field of the IP header set to 1 (ICMP) and the type field in the ICMP header set to 13 (Timestamp Request).
2008	400018	ICMP Timestamp Reply	Informational	Triggers when a IP datagram is received with the protocol field of the IP header set to 1 (ICMP) and the type field in the ICMP header set to 14 (Timestamp Reply).

Signature ID	Message Number	Signature Title	Signature Type	Description
2009	400019	ICMP Information Request	Informational	Triggers when a IP datagram is received with the protocol field of the IP header set to 1 (ICMP) and the type field in the ICMP header set to 15 (Information Request).
2010	400020	ICMP Information Reply	Informational	Triggers when a IP datagram is received with the protocol field of the IP header set to 1 (ICMP) and the type field in the ICMP header set to 16 (ICMP Information Reply).
2011	400021	ICMP Address Mask Request	Informational	Triggers when a IP datagram is received with the protocol field of the IP header set to 1 (ICMP) and the type field in the ICMP header set to 17 (Address Mask Request).
2012	400022	ICMP Address Mask Reply	Informational	Triggers when a IP datagram is received with the protocol field of the IP header set to 1 (ICMP) and the type field in the ICMP header set to 18 (Address Mask Reply).
2150	400023	Fragmented ICMP Traffic	Attack	Triggers when a IP datagram is received with the protocol field of the IP header set to 1 (ICMP) and either the more fragments flag is set to 1 (ICMP) or there is an offset indicated in the offset field.
2151	400024	Large ICMP Traffic	Attack	Triggers when a IP datagram is received with the protocol field of the IP header set to 1(ICMP) and the IP length > 1024.

Signature ID	Message Number	Signature Title	Signature Type	Description
2154	400025	Ping of Death Attack	Attack	Triggers when a IP datagram is received with the protocol field of the IP header set to 1(ICMP), the Last Fragment bit is set, and (IP offset * 8) + (IP data length) > 65535 that is to say, the IP offset (which represents the starting position of this fragment in the original packet, and which is in 8 byte units) plus the rest of the packet is greater than the maximum size for an IP packet.
3040	400026	TCP NULL flags	Attack	Triggers when a single TCP packet with none of the SYN, FIN, ACK, or RST flags set has been sent to a specific host.
3041	400027	TCP SYN+FIN flags	Attack	Triggers when a single TCP packet with the SYN and FIN flags are set and is sent to a specific host.
3042	400028	TCP FIN only flags	Attack	Triggers when a single orphaned TCP FIN packet is sent to a privileged port (having port number less than 1024) on a specific host.
3153	400029	FTP Improper Address Specified	Informational	Triggers if a port command is issued with an address that is not the same as the requesting host.
3154	400030	FTP Improper Port Specified	Informational	Triggers if a port command is issued with a data port specified that is <1024 or >65535.
4050	400031	UDP Bomb attack	Attack	Triggers when the UDP length specified is less than the IP length specified. This malformed packet type is associated with a denial of service attempt.
4051	400032	UDP Snork attack	Attack	Triggers when a UDP packet with a source port of either 135, 7, or 19 and a destination port of 135 is detected.

Signature ID	Message Number	Signature Title	Signature Type	Description
4052	400033	UDP Chargen DoS attack	Attack	This signature triggers when a UDP packet is detected with a source port of 7 and a destination port of 19.
6050	400034	DNS HINFO Request	Informational	Triggers on an attempt to access HINFO records from a DNS server.
6051	400035	DNS Zone Transfer	Informational	Triggers on normal DNS zone transfers, in which the source port is 53.
6052	400036	DNS Zone Transfer from High Port	Informational	Triggers on an illegitimate DNS zone transfer, in which the source port is not equal to 53.
6053	400037	DNS Request for All Records	Informational	Triggers on a DNS request for all records.
6100	400038	RPC Port Registration	Informational	Triggers when attempts are made to register new RPC services on a target host.
6101	400039	RPC Port Unregistration	Informational	Triggers when attempts are made to unregister existing RPC services on a target host.
6102	400040	RPC Dump	Informational	Triggers when an RPC dump request is issued to a target host.
6103	400041	Proxied RPC Request	Attack	Triggers when a proxied RPC request is sent to the portmapper of a target host.
6150	400042	ypserv (YP server daemon) Portmap Request	Informational	Triggers when a request is made to the portmapper for the YP server daemon (ypserv) port.
6151	400043	ypbind (YP bind daemon) Portmap Request	Informational	Triggers when a request is made to the portmapper for the YP bind daemon (ypbind) port.

Signature ID	Message Number	Signature Title	Signature Type	Description
6152	400044	yppasswdd (YP password daemon) Portmap Request	Informational	Triggers when a request is made to the portmapper for the YP password daemon (yppasswdd) port.
6153	400045	ypupdated (YP update daemon) Portmap Request	Informational	Triggers when a request is made to the portmapper for the YP update daemon (ypupdated) port.
6154	400046	ypxfrd (YP transfer daemon) Portmap Request	Informational	Triggers when a request is made to the portmapper for the YP transfer daemon (ypxfrd) port.
6155	400047	mountd (mount daemon) Portmap Request	Informational	Triggers when a request is made to the portmapper for the mount daemon (mountd) port.
6175	400048	rexd (remote execution daemon) Portmap Request	Informational	Triggers when a request is made to the portmapper for the remote execution daemon (rexd) port.
6180	400049	rexd (remote execution daemon) Attempt	Informational	Triggers when a call to the rexd program is made. The remote execution daemon is the server responsible for remote program execution. This may be indicative of an attempt to gain unauthorized access to system resources.
6190	400050	statd Buffer Overflow	Attack	Triggers when a large statd request is sent. This could be an attempt to overflow a buffer and gain access to system resources.

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