Refer to the following sections for information about these topics:

- **9-1: Managing the Firewall Clock**—Discusses ways to set and maintain the firewall's internal clock so that events and messages can have accurate time stamps.
- **9-2: Generating Logging Messages**—Explains how firewalls generate logging messages and how you can configure them to do that.
- **9-3: Fine-Tuning Logging Message Generation**—Covers the configuration steps that can be used to enable or disable specific logging messages or change their severity levels. This section also discusses how to configure access list activity logging.
- **9-4: Analyzing Firewall Logs**—Provides an overview of how you can approach collecting and analyzing the logging messages that firewalls produce.

CHAPTER 9

Firewall Logging

Cisco firewalls and security appliances can be configured to generate an audit trail of messages describing their activities. Firewall logs can be collected and analyzed to determine what types of traffic have been permitted or denied, what users have accessed various resources, and so on.

This chapter presents the tasks that are necessary to begin generating and collecting logging messages.

9-1: Managing the Firewall Clock

A Cisco firewall keeps an internal clock that can be used for Syslog time stamps, certificate time stamps, and so on. The clock is powered by a battery in the absence of regular power.

The internal clock is always based on Coordinated Universal Time (UTC). UTC was previously known as Greenwich Mean Time (GMT).

You can set the system time using two different approaches:

- **Manually**—You set the time and date on the firewall along with the time zone and specify whether to observe daylight savings time. With manual configuration, the firewall clock is only as accurate as the internal clock hardware.
- **Using Network Time Protocol (NTP)**—This is a protocol defined by RFC 1305 that provides a mechanism for the devices in the network to get their time from an NTP server. With NTP, all the devices are synchronized to a common, trusted source and keep very accurate time.

NTP uses the concept of *stratum* to determine how close an NTP server is to an authoritative time source (an atomic or radio clock). Stratum 1 means that an NTP server is directly connected to an authoritative time source. NTP also compares the times reported from all configured NTP peers and does not listen to a peer that has a significantly different time.

NTP associations with other NTP peers can be protected through an encrypted authentication.

TIP NTP version 3 is based on RFC 1305 and uses UDP port 123. Information about public NTP servers and other NTP subjects can be found at http://www.ntp.org.

You can also use a commercial product as your own stratum 1 time source. For example, Symmetricom (http://www.ntp-systems.com/products.asp) offers several NTP time servers that are based on Global Positioning Satellite (GPS) signals.

Setting the Clock Manually

1. (Optional) Identify the time zone:

```
Firewall(config)# clock timezone zone-name hours [minutes]
```

zone-name is the time zone (an arbitrary text string such as EST) and is *hours* (0 to 12 or 0 to –12) and optionally *minutes* offset from UTC. For example, Eastern Standard Time in the U.S. is 5 hours behind UTC and would be configured as follows:

```
Firewall(config)# clock timezone EST -5
```

2. (Optional) Set daylight savings time (summer time) parameters.

   a. Use the following command if daylight savings time recurs at regular intervals:

```
Firewall(config)# clock summer-time zone recurring [week weekday month
  hh:mm week weekday month hh:mm] [offset]
```

If daylight savings time begins and ends on a certain day and week of a month, you can use this command. The name of the daylight savings time zone is given as *zone* (an arbitrary name or abbreviation, such as EDT). The week number *week* (1 to 4 or the words "first" and "last"), the name of the *weekday*, the name of the *month* (only the first three letters matter), and the time *hh:mm* in 24-hour format can all be given to start and stop daylight savings time. The *offset* value gives the number of minutes to add during daylight savings time (the default is 60 minutes).

For example, daylight savings time in the U.S. begins at 2 a.m. on the first Sunday in April and ends at 2 a.m. on the last Sunday in October. You could define it with this command:

```
Firewall(config)# clock summer-time EDT recurring first Sunday april
  2:00 last Sunday oct 2:00 60
```

TIP You can use the **recurring** keyword with no other arguments for any of the U.S. and Canadian time zones. The correct begin and end dates are used automatically. For the preceding example, you could define daylight savings time as follows:

```
Firewall(config)# clock summer-time EDT recurring
```

b. If daylight savings time occurs at specific times, you can use the following command to specify the exact date and time that daylight savings time begins and ends in a given year:

```
Firewall(config)# clock summer-time zone date {day month ¦ month day}
year hh:mm {day month ¦ month day} year hh:mm [offset]
```

This command is useful if the begin and end times change from year to year. Specify the year number as *year* (four digits, 1993 to 2035).

3. Set the firewall clock:

```
Firewall(config)# clock set hh:mm:ss {day month ¦ month day} year
```

The clock is set when this command is executed. The time is given in 24-hour format, *day* is the day number (1 to 31), *month* is the name of the month (only the first three letters are needed), and *year* is the full four-digit year. The *day* and *month* parameters can be reversed, according to what is customary.

4. Verify the clock:

```
Firewall# show clock [detail]
```

The current time and date are shown. If you use the **detail** keyword, the source of the time ("hardware calendar" is the internal battery-operated clock) and any daylight savings time definitions are shown, as in this example:

```
Firewall# show clock detail
13:54:21.793 EST Sat Oct 1 2005
Time source is hardware calendar
Summer time starts 02:00:00 EST Sun Apr 4 2005
Summer time ends 02:00:00 EDT Sun Oct 31 2005
Firewall#
```

Setting the Clock with NTP

TIP In PIX 7.x multiple-context mode, NTP must be configured on the system execution space only. All the other contexts (both admin and user) obtain their clock information from the system execution space, because all the contexts exist in the same physical firewall. You can use the **changeto system** command to move your session into the system execution space before using the following configuration steps.

The Firewall Services Module (FWSM) doesn't have a standalone clock, and it doesn't support NTP. Because it is a module inside a Catalyst 6500 chassis, it relies on the switch clock instead. Therefore, you should make sure the switch has been configured for NTP as an accurate clock source.

1. (Optional) Use NTP authentication.

   a. Define an authentication key:

   ```
   Firewall(config)# ntp authentication-key key-number md5 value
   ```

   An MD5 authentication key numbered *key-number* (1 to 4294967295) is created. The key is given a text-string *value* of up to eight cleartext characters. After the configuration is written to Flash memory, the key value is displayed in its encrypted form.

   You can repeat this command to define additional keys if needed.

   b. (Optional) Identify a key to expect from all defined NTP servers:

   ```
   Firewall(config)# ntp trusted-key key-number
   ```

   Remote NTP peers must authenticate themselves with the firewall using the authentication key numbered *key-number* (1 to 4294967295), as defined in Step 1a. If this command is used, any NTP server must supply this key to the firewall before its time update information is accepted. You can repeat this command to identify additional keys to expect. (Trusted keys can also be defined on a per-server basis in Step 2.)

   c. Enable NTP authentication:

   ```
   Firewall(config)# ntp authenticate
   ```

2. Specify an NTP server:

   ```
   Firewall(config)# ntp server ip-address [key number] [source if-name]
     [prefer]
   ```

   The NTP peer (server) is identified at *ip-address*. If you are using NTP authentication, you can use the **key** keyword to identify which authentication key to expect from this server. (See Step 1a.) By default, the firewall sends NTP packets on the interface derived from its routing table. You can specify an interface to use with the **source** keyword and the interface named *if-name* (**outside** or **inside**, for example).

   You can repeat this command to define more than one NTP server. If one server is down or unavailable, a second or third server could be used to synchronize time. You can use the **prefer** keyword to indicate one NTP server that is preferred if multiple NTP servers are configured.

TIP Actually, a firewall using NTP can use its associations with several servers to derive a more accurate idea of the time. If possible, you should configure a minimum of three different NTP servers so that your firewall can determine if any one of them is inaccurate.

3. Verify NTP operation.

   a. Verify the NTP configuration commands:

PIX 6.x	`Firewall# show ntp`
PIX 7.x	`Firewall# show running-config ntp`

   This command displays the commands but not any information about NTP operation, as in this example:

```
Firewall# show running-config ntp
ntp authentication-key 1 md5 *
ntp authentication-key 2 md5 *
ntp authenticate
ntp server 192.168.254.4 key 1 source inside prefer
ntp server 192.168.254.3 key 2 source inside
Firewall#
```

   Notice that the MD5 hash keys are automatically hidden from being displayed in the configuration. Instead, only an asterisk is shown.

   b. Verify the current NTP status:

```
Firewall# show ntp status
```

   NTP should be in the synchronized state if the firewall has successfully authenticated and exchanged information with at least one NTP server. This command shows this in the first line of output, as shown in the following example. Notice that the firewall has become a stratum 4 time source itself, deriving its time information from a higher (lower-stratum) authority:

```
Firewall# show ntp status
Clock is synchronized, stratum 4, reference is 192.168.254.4
nominal freq is 99.9984 Hz, actual freq is 99.9984 Hz, precision is 2**6
reference time is c34d3659.655d8a23 (14:28:25.395 EST Fri Oct 31 2003)
clock offset is 10.8642 msec, root delay is 87.74 msec
root dispersion is 15927.54 msec, peer dispersion is 15875.02 msec
Firewall#
```

   If the clock is unsynchronized, the firewall has not yet authenticated or synchronized its time clock with an NTP server. Keep checking the status every minute or so to see if the clock becomes synchronized. If it doesn't, confirm your NTP configuration and authentication keys.

   c. View all NTP server associations:

```
Firewall# show ntp associations [detail]
```

   The firewall clock becomes synchronized with only one NTP server. However, it keeps an association with each NTP server that is configured. NTP continuously compares clock

information from all known servers so that it can maintain the most accurate time. In the following example, the firewall has associations with two NTP servers:

```
Firewall# show ntp associations
      address         ref clock     st  when  poll reach  delay  offset
    disp
*~192.168.254.4    198.82.162.213    3    21    64    3    14.8   10.86
    7889.6
+~192.168.254.3    198.82.162.213    3    10    64    3     2.5    0.31
    7881.1
 * master (synced), # master (unsynced), + selected, - candidate,
  ~ configured
Firewall#
```

Notice that the two NTP servers are shown (each is stratum 3 in the **st** column), along with the reference clock that each uses. Here, 192.168.254.4 has become the preferred, or "master," source of synchronization, designated by the * flag. The 192.168.254.3 server is marked with +, indicating that it is selected for possible synchronization.

If you find that some of the server addresses are not selected or synchronized, you can get more information about the failed associations by adding the **detail** keyword.

TIP If you are having trouble getting a firewall to synchronize its clock, you can use the **debug ntp authentication** EXEC command (if the NTP server requires authentication) or the **debug ntp** {**events** | **select** | **sync**} command to watch the exchange of NTP information. The debug output is shown only in the "debug trace" channel, which is usually the first Telnet or SSH session active on the firewall. If there are no Telnet or SSH sessions, the output is sent to the console.

9-2: Generating Logging Messages

The firewall uses logging to send system messages to one or more logging destinations, where they can be collected, archived, and reviewed.

Messages are generated according to a *severity level*, specified by a number (0 through 7) or a keyword, as shown in Table 9-1.

Table 9-1 *System Message Severity Levels*

Severity Level	Description
0: emergencies	The system is unusable
1: alerts	Immediate action is required

Table 9-1 *System Message Severity Levels (Continued)*

Severity Level	Description
2: critical	A critical condition exists
3: errors	Error message
4: warnings	Warning message
5: notifications	A normal but significant condition
6: informational	Information message
7: debugging	Debug output and very detailed logs

Logging messages can be sent to any of the following destinations:

- The firewall console
- Telnet or SSH sessions to the firewall
- A temporary buffer internal to the firewall
- SNMP management stations
- Syslog servers
- Firewall management applications such as Cisco Adaptive Security Device Manager (ASDM 5.0) and Cisco PIX Device Manager (PDM 3.0 and 4.0)
- E-mail addresses (PIX 7.x only)
- An FTP server (PIX 7.x only)
- Firewall Flash (PIX 7.x only)

The logging level can be set to determine which messages should be sent to each of the destinations. When you set a severity level for a destination, all messages with a lower severity level are also sent.

You should always add time stamps to Syslog messages to help in real-time debugging and management. The firewall can add time stamps as messages are generated, or a Syslog server can add time stamps as messages are received.

TIP You should have all your network devices use a common time reference point so that all the time stamps on all logging messages are synchronized. You can do this by configuring firewalls, routers, and switches to use one or more authoritative NTP servers as a time source.

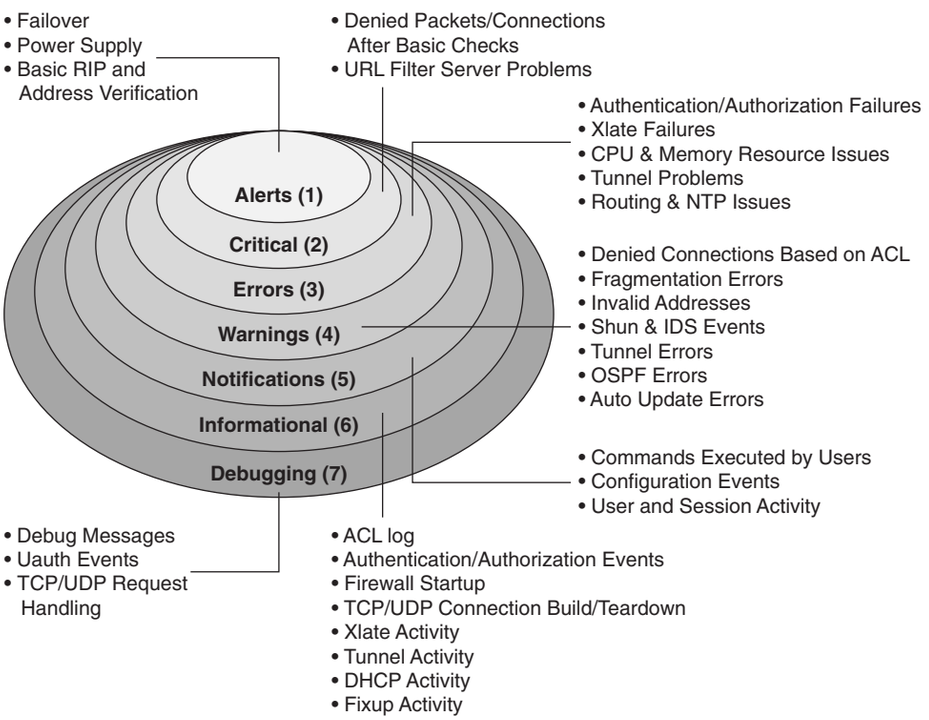
If you have some NTP servers inside your network, each network device can synchronize time with them. However, if you intend to use NTP servers on the public Internet, you should use a hierarchical approach. Select two routers within your network to synchronize time with the Internet servers. Optimally, each router should peer with three unique time sources so that none of them are duplicated.

Then point all your inside devices to synchronize time with the routers. The idea is to contain the bulk of NTP synchronizations within your network rather than have a multitude of hosts peering with the Internet servers.

You can configure a unique "device ID" so that logging messages from a firewall can be readily identified. This becomes important when one Syslog server collects messages from many different firewalls, routers, and switches.

Figure 9-1 shows each of the logging severity levels, along with a general list of the types of messages generated. Each level also includes every level below it. The higher the severity level, the more types of messages that are included.

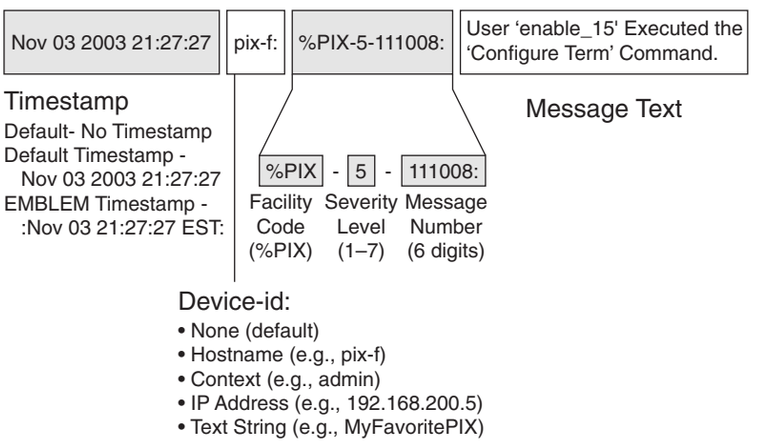
Figure 9-1 *Syslog Severity Levels and Their Messages*



System messages are logged in either the default or EMBLEM format. Figure 9-2 shows the default message format. Each message has the following fields:

- **Time stamp**—The date and time from the firewall clock. The default is no time stamp.
- **Device ID**—Added to uniquely identify the firewall generating the message. Can be the firewall's host name, an interface IP address, or an arbitrary text string. The default is no device-id.
- **Message ID**—Always begins with **%PIX-**, **%ASA-**, or **%FWSM-**, followed by the severity level and the six-digit message number.
- **Message text**—A description of the event or condition that triggered the message.

Figure 9-2 *Firewall Logging Message Format*



The EMBLEM format is used primarily for the CiscoWorks Resource Manager Essentials (RME) Syslog analyzer. This format matches the Cisco IOS Software Syslog format produced by routers and switches. It is available only to UDP Syslog servers.

NOTE By default, logging to a Syslog server uses UDP port 514 or TCP port 1468. Sending logging messages via SNMP traps uses UDP port 162. UDP is usually used as an efficient, "best-effort" method. TCP is used when Syslog collection is a vital part of enterprise security, because its delivery is reliable.

The six-digit message numbers are arbitrarily defined by Cisco and uniquely identify each logging message. You can look up message numbers and their meanings in Appendix B, "Security Appliance Logging Messages."

Syslog Server Suggestions

To make full use of the logging messages generated by a firewall, you need a Syslog server application running somewhere in your network. Some recommendations for Syslog servers are as follows:

- **Kiwi Syslog Daemon**—A commercial Syslog server for Windows-based platforms, available at http://www.kiwisyslog.com
- **UNIX syslogd**—A Syslog daemon built into most versions of the UNIX operating system
- **Cisco PIX Firewall Syslog Server (PFSS)**—A Syslog server available in the Cisco.com Software Center under PIX Firewall Software
- **CiscoWorks 2000**—A Syslog server built into the RME module of the base CiscoWorks 2000 package
- **CiscoWorks VPN/Security Management Solution (VMS)**—A Syslog server available as a part of the Monitoring Center for Security component of VMS

- **Syslog server**—Available as a part of the Network Security Analyzer and FirewallAnalyzer products from eIQnetworks at http://www.eiqnetworks.com
- **Sawmill**—A Syslog server and analysis application that runs on a wide variety of platforms, available from FlowerFire at http://www.sawmill.net

If you have a large network with firewalls that generate a large amount of Syslog information, an average Syslog server software application might become overwhelmed with the load. The end result is that logging messages are lost or that the Syslog server runs out of storage space.

In this case, you should consider moving the Syslog resources to a hardware platform. Some examples of hardware appliances are as follows:

- **Cisco CS-MARS**—Appliances that offer Syslog collection and analysis, along with many other security analysis and mitigation features, at a high volume. Available from Cisco Systems at http://www.cisco.com/en/US/products/ps6241/index.html.
- **Network Intelligence Engine**—Appliances that collect, analyze, and manage Syslog messages at a high volume. Available from Network Intelligence Corporation at http://www.network-intelligence.com.

TIP Alternatively, you can adjust the severity level for the logging destination so that a lower value is used. This reduces the number and type of messages produced but also reduces the amount of useful information that can be collected and analyzed.

Logging Configuration

A firewall can be configured to send logging information to one or more destinations. In PIX 6.3 and FWSM 2.2, each destination can have only one severity level associated with it, so only messages at or below that severity level are actually sent.

This tends to limit any customization if you need to filter or collect only specific types of information at a destination. For example, if you set a Syslog server destination to collect messages at or below the "notifications" level, you can't collect any useful information from messages that have a default severity of "informational."

To get around this, you can adjust the default severity level of individual logging message IDs. Suppose your destination is configured to collect at level "notifications." There might be some useful messages that have a default level of "informational" or "debugging" that would not be sent to that destination because their default severity levels are greater than that of the destination. You can change those message IDs to have a new severity level of "notifications" so that they are sent too.

PIX 7.x Logging Filters

PIX 7.x includes more flexible logging functionality. As before, each logging destination can have one overall severity threshold. If any message is generated, it is sent only if its severity level is at or below this threshold.

However, logging destinations can have a severity threshold that is dependent on several conditions. Think of this as defining a *logging policy* for a destination, where you can pick and choose messages to be collected based on certain criteria. For each destination, you can assign *one* of the following:

- An overall severity level threshold
- A logging policy, defined as a "logging list"

The logging list is made up of one or more policy statements. When a logging message is generated, it is sent if any policy statement is matched. A logging list can be made up of any of the following:

- A severity level threshold for specific classes of messages
- An overall severity level threshold
- Specific logging message IDs to match against

In addition, you can configure messages from a predefined class of messages to appear at one or more destinations at configurable severity levels. Any message within the logging class is sent to a destination if it is at or below the severity level threshold configured for that destination.

PIX 7.x provides these predefined classes of logging messages:

- **auth**—User authentication messages
- **bridge**—Transparent firewall messages
- **ca**—PKI certificate authority messages
- **config**—Firewall configuration and EXEC commands via the command-line interface (CLI)
- **ha**—Failover messages
- **ids**—Intrusion Detection System messages
- **ip**—TCP/IP inspection messages
- **np**—Network processor messages
- **ospf**—OSPF routing messages
- **rip**—RIP routing messages
- **rm**—Firewall Resource Manager messages
- **session**—Firewall user session messages
- **snmp**—SNMP messages
- **sys**—System messages
- **vpdn**—PPTP and L2TP session messages
- **vpn**—IKE and IPSec messages

- **vpnc**—VPN client messages
- **vpnfo**—VPN failover messages
- **vpnlb**—VPN load-balancing messages
- **webvpn**—WebVPN client messages

Logging policies and logging class definitions are configured in Steps 2 and 3, respectively.

Logging Configuration Steps

1. Enable message logging.

   a. Begin sending logging messages to all configured destinations:

FWSM 2.x	`Firewall(config)# logging on`
PIX 6.x	`Firewall(config)# logging on`
PIX 7.x	`Firewall(config)# logging enable`

   By default, logging is globally disabled, even if it is configured for one or more destinations. To begin logging, you must use this command.

   b. (Optional) Limit the rate at which logging messages are generated:

FWSM 2.x	`Firewall(config)# logging rate-limit {unlimited ¦ number [interval]} {level level ¦ message message_id}`
PIX 6.x	—
PIX 7.x	—

   You can rate-limit messages being generated at a specific severity level by using the **level** keyword, where *level* is **emergencies** (**0**), **alerts** (**1**), **critical** (**2**), **errors** (**3**), **warnings** (**4**), **notifications** (**5**), **informational** (**6**), or **debugging** (**7**). Note that this affects messages only at the severity level specified. Messages at lower or higher levels are not rate-limited.

   You can also rate-limit specific messages being generated with the **message** keyword, where *message_id* is a six-digit number (as defined in Appendix B).

   Logging messages meeting these criteria are sent at a maximum of *number* (0 to 2147483647, where 0 is unlimited) messages per *interval* (0 to 2147483647) seconds. The interval defaults to 1 second if not specified. By default, rate limiting is unlimited on all platforms.

   For example, the following commands limit all debugging (severity level 7) messages so that up to 50 message per second are generated. In addition, message ID 106015 (deny TCP/no connection) is limited to 10 messages per second.

```
Firewall(config)# logging rate-limit 50 1 level debugging
Firewall(config)# logging rate-limit 10 1 message 106015
```

NOTE Rate limiting is applied to a severity level or message ID. It is not applied to a destination. Therefore, rate limiting affects the volume of messages being sent to *all* configured destinations.

2. (PIX 7.x only) Define a logging policy with an event list.

The event list is defined by its name and can consist of one or more **logging list** commands. Logging messages are matched against the event list as they are generated. If a match is found, the message is allowed to be sent.

Logging lists can be configured with the commands shown in this step. A logging list policy is actually applied when the severity level is configured for a specific logging destination in Steps 4 through 9 in this list.

TIP If a logging list has been configured and applied to a destination, it can't be modified until it is removed or unbound from the destination. You can unbind a logging list by reissuing the **logging** *destination level* command, omitting the logging list name.

a. (Optional) Match against a severity level:

FWSM 2.x	—
PIX 6.x	—
PIX 7.x	`Firewall(config)# logging list event_list level level [class event_class]`

The event list named *event_list* matches any Syslog message at or below one of the following severity *level* keywords or numbers: **emergencies** (**0**), **alerts** (**1**), **critical** (**2**), **errors** (**3**), **warnings** (**4**), **notifications** (**5**), **informational** (**6**), or **debugging** (**7**).

You can also narrow the matching criteria by using a predefined "class" of Syslog message types. Use the **class** keyword with one of the following *event_class* names: **auth**, **bridge**, **ca**, **config**, **ha**, **ids**, **ip**, **np**, **ospf**, **rip**, **rm**, **session**, **snmp**, **sys**, **vpdn**, **vpn**, **vpnc**, **vpnfo**, **vpnlb**, or **webvpn**.

For example, the following commands can be used to match all logging messages at the notifications level and all IP-related messages (xlate and conn build/teardown and ACL activity) at the debugging level. Now the destination can collect various types of messages from multiple severity levels.

```
Firewall(config)# logging list MyList level notifications
Firewall(config)# logging list MyList level debugging class ip
```

b. (Optional) Match specific Syslog message IDs:

FWSM 2.x	—
PIX 6.x	—
PIX 7.x	`Firewall(config)# logging list` *event_list* `message` *start*`[-`*end*`]`

The event list named *event_list* matches any of the Syslog messages defined by the ID range *start* to *end* (100000 to 999999). If no *end* value is given, *start* defines a single message ID.

For example, suppose the logging list **xlate-log** is used to log messages related to address translation. Message 202001 (**out of translation slots**) and messages 305009 through 305011 (**translations built and torn down**) can be used to collect an audit trail of dynamic xlate entries (using the following commands) so that inside users can be associated with PAT addresses at any given time:

```
Firewall(config)# logging list xlate-log message 202001
Firewall(config)# logging list xlate-log message 305009-305011
```

3. (PIX 7.x only) Define destinations for a logging class of messages:

FWSM 2.x	—
PIX 6.x	—
PIX 7.x	`Firewall(config)# logging class` *event_class destination level* `[`*destination level*`] [`*destination level*`] ...`

You can configure a predefined class of logging messages to be sent to one or more logging destinations, each having a unique severity threshold. The class is identified by one of the following *event_class* names: **auth**, **bridge**, **ca**, **config**, **ha**, **ids**, **ip**, **np**, **ospf**, **rip**, **rm**, **session**, **snmp**, **sys**, **vpdn**, **vpn**, **vpnc**, **vpnfo**, **vpnlb**, or **webvpn**.

You can define one or more destinations and severity threshold pairs for the class using a single command line. Each *destination* must be one of the following keywords: **console** (firewall console), **monitor** (Telnet or SSH session), **buffered** (memory buffer), **trap** (Syslog servers), **history** (SNMP traps), **mail** (SMTP), **pdm** (PDM application for FWSM 2.x or PIX 6.x), or **asdm** (ASDM application for PIX 7.x).

Each severity *level* must be one of the following keywords or numbers: **emergencies** (**0**), **alerts** (**1**), **critical** (**2**), **errors** (**3**), **warnings** (**4**), **notifications** (**5**), **informational** (**6**), or **debugging** (**7**).

For example, in the following command, high-availability messages of severity 1 (alerts) are sent to the trap destination, and severity 7 (debugging) messages are sent to the logging buffer:

```
Firewall(config)# logging class ha trap alerts buffered debugging
```

4. (Optional) Log to an interactive firewall session.

   a. (Optional) Log to the firewall console:

FWSM 2.x	`Firewall(config)# logging console level`
PIX 6.x	`Firewall(config)# logging console level`
PIX 7.x	`Firewall(config)# logging console {level ¦ event-list}`

   If you have a terminal emulator connected to the firewall console, you might want to see logging messages as they are generated. Messages are displayed if they are at or below the specified severity *level*: **emergencies** (**0**), **alerts** (**1**), **critical** (**2**), **errors** (**3**), **warnings** (**4**), **notifications** (**5**), **informational** (**6**), or **debugging** (**7**).

   Beginning in PIX 7.x, you can also use a policy to select which messages are displayed. Messages that are matched by the event list named *event-list* (defined in Step 2) are forwarded to the logging destination. Keep in mind that PIX 7.x in multiple-context mode still has only one physical console port. Therefore, it doesn't make sense to enable console logging for a user context, because those contexts don't have a usable console.

CAUTION You should send logging messages to the serial console only if the firewall is lightly loaded or in a test environment. Messages are displayed at a relatively low speed (9600 baud); if many messages are generated, the backlog of messages can cause the firewall to have slow response. As well, you lose interactive control at the console while the messages are being displayed.

For these reasons, console logging is disabled by default.

   b. (Optional) Log to Telnet or SSH sessions on the firewall:

FWSM 2.x	`Firewall(config)# logging monitor level`
PIX 6.x	`Firewall(config)# logging monitor level`
PIX 7.x	`Firewall(config)# logging monitor {level ¦ event-list}`

   If you have a remote firewall Telnet or SSH session open, you might want to see logging messages as they are generated. Messages are displayed if they are at or below the specified severity *level*: **emergencies** (**0**), **alerts** (**1**), **critical** (**2**), **errors** (**3**), **warnings** (**4**), **notifications** (**5**), **informational** (**6**), or **debugging** (**7**).

   To see the logging messages in the current session as they are generated, use the **terminal monitor** EXEC command. (In PIX 6.3, you must be in configuration mode to use this command. In addition, the most recently initiated Telnet session receives the session log-

ging output by default, because **terminal monitor** mode is active until it is disabled.) To stop seeing the messages, use the EXEC command **terminal no monitor**.

With PIX 7.x, you can also use a policy to select which messages are displayed. Messages that are matched by the event list named *event-list* (defined in Step 2) are forwarded to the logging destination.

CAUTION You should avoid sending logging messages to Telnet and SSH sessions on a highly utilized production firewall. Although logging messages can be sent to interactive sessions more efficiently than the firewall console, the firewall can still become backlogged with messages to send. Therefore, monitor (session) logging is disabled by default.

5. (Optional) Log to the firewall's internal buffer.

   Internal buffered logging uses a 4096-byte circular memory buffer to store the most recent messages. The actual number of logging messages stored depends on the length of each message. For example, one full buffer might contain only 32 messages if those lines of message text are very long.

   TIP The logging buffer can be handy if you don't have access to a Syslog server or if the Syslog server is unavailable. The logging buffer is the most efficient way to collect some messages for troubleshooting or to inspect specific activity without having to sift through massive Syslog server logs. You might want to see only certain types of messages that are being generated, even though a wide variety of logging messages are being sent to a Syslog server.

   In addition, the logging buffer is much more efficient than sending logging output to the firewall console or a Telnet or SSH session. Think of the logging buffer as a small collector for occasional use.

   a. Set the buffer logging level:

FWSM 2.x	`Firewall(config)# logging buffered level`
PIX 6.x	`Firewall(config)# logging buffered level`
PIX 7.x	`Firewall(config)# logging buffered {level ¦ event-list}`

The firewall keeps a circular buffer in memory that can hold the most recent logging messages. Messages are sent to the buffer if they are at or below the specified severity *level*: **emergencies** (**0**), **alerts** (**1**), **critical** (**2**), **errors** (**3**), **warnings** (**4**), **notifications** (**5**), **informational** (**6**), or **debugging** (**7**).

Beginning in PIX 7.x, you can also use a policy to select which messages are displayed. Messages that are matched by the event list named *event_list* (defined in Step 2) are forwarded to the logging destination.

By default, the buffer is 4096 bytes long and can hold about 100 messages. PIX 7.x allows you to adjust the size of the buffer if needed. You can use the **logging buffer-size** *bytes* command to size the buffer to 4096 to 1048576 bytes.

To see the buffered messages, use the EXEC command **show logging**. Remember that the buffer is circular, so it never overflows and never needs clearing. However, you can clear the buffer with the **clear logging buffer** command if you need to see only the most recent messages collected after a certain point.

b. (Optional) Copy the buffer via FTP if it fills and wraps:

FWSM 2.x	—
PIX 6.x	—
PIX 7.x	`Firewall(config)# logging ftp-bufferwrap` `Firewall(config)# logging ftp-server` *`ftp_server path username password`*

When the circular logging buffer is full (is getting ready to wrap around itself), the firewall can copy a snapshot of it to an FTP server at IP address *ftp_server*. The firewall connects to the server using *username* and *password*.

The buffer contents are uploaded as a file stored at the path name *path*. The path name is relative to the username's directory on the server. For example, to save the log file into user hucaby's home directory, you can use the "." current directory path name. The firewall automatically names the log file in the form LOG-*YYYY-MM-DD-HHMMSS*.TXT (where *YYYY-MM-DD* represents the date and *HHMMSS* represents the time). The log file is always the total size of the logging buffer (4096 bytes by default).

For example, you could use the following commands to force the logging buffer contents to be uploaded to an FTP server into the home directory of user pixadmin:

```
Firewall(config)# logging ftp-bufferwrap
Firewall(config)# logging ftp-server 1992.168.199.10 . pixadmin
  bigsecretpw
```

TIP If you experience problems getting the firewall to successfully upload log files to the FTP server, you might see the following error messages:

```
pix/admin# ERROR: ftp write to server 192.168.3.14 failed:
%PIX-3-414001: Failed to save logging buffer to FTP server 192.168.3.14
  using filename LOG-2004-11-06-010113.TXT on interface inside:
```

You can use the **debug ftp client** command to see debugging output as the firewall attempts to upload its log files. Make sure you have a logging destination configured for the debugging severity, as well as for the debug-trace output.

From this information, you should be able to see where the process fails. Consider the following example, in which the firewall successfully logs into the FTP server but the server rejects the log file path name because it isn't relative to the user's directory:

```
Firewall# debug ftp client
[time passes until buffer wraps]
%PIX-7-711001: Writing /pix-log-snapshot/LOG-2004-11-06-010703.TXT
%PIX-7-711001: FTP: 220 pi FTP server ready.
%PIX-7-711001: FTP: ---> USER pixadmin
%PIX-7-711001: FTP: 331 Password required for pixadmin.
%PIX-7-711001: FTP: ---> PASS *
%PIX-7-711001: FTP: 230 User pixadmin logged in.
%PIX-7-711001: FTP: ---> TYPE I
%PIX-7-711001: FTP: 200 Type set to I.
%PIX-7-711001: FTP: ---> PORT 192,168,93,135,4,100
%PIX-7-711001: FTP: 200 PORT command successful.
%PIX-7-711001: FTP: ---> STOR /pix-log-snapshot/LOG-2004-11-06-010703.TXT
%PIX-7-711001: FTP: 553 /pix-log-snapshot/LOG-2004-11-06-010703.TXT: No
  such file or directory.
%PIX-7-711001: FTP: ---> QUIT
%PIX-3-414001: Failed to save logging buffer to FTP server 192.168.3.14
  using filename LOG-2004-11-06-010703.TXT on interface inside:
%PIX-7-711001: FTP: 221 Goodbye.
```

c. (Optional) Copy the buffer to Flash if it fills and wraps:

FWSM 2.x	—
PIX 6.x	—
PIX 7.x	`Firewall(config)# logging flash-bufferwrap` `Firewall(config)# logging flash-minimum-free` *kbytes_free* `Firewall(config)# logging flash-maximum-allocation` *kbytes_max*

When the circular logging buffer gets ready to wrap, the firewall can copy a snapshot of it into a file on the Flash file system. The firewall automatically names the log file in the Syslog Flash directory using a filename of the form LOG-*YYYY-MM-DD-HHMMSS*.TXT (where *YYYY-MM-DD* represents the date and *HHMMSS* represents the time). The log file is always the total size of the logging buffer (4096 bytes by default).

As more log files are saved, more space in the Flash file system is used up. With the **flash-maximum-allocation** keyword, you can limit the total space reserved for log files to *kbytes_max* (4 to 15750 KB). The **flash-minimum-free** keyword specifies how much Flash memory must be free before log files can be saved, as *kbytes_free* (0 to 15750 KB).

TIP Flash-related logging buffer commands are available only in PIX 7.x running in single-context mode. If multiple contexts are being used, only the system execution space has access to the Flash file system. However, its logging capability is very limited because most of the firewall activity occurs in other contexts.

In single-context mode, you can manually save the current buffer contents into Flash by using the following command in privileged EXEC mode:

```
Firewall# logging savelog [savefile]
```

The log file is saved in the Syslog directory of the Flash file system. You can specify a filename *savefile* for it. Otherwise, the default filename template LOG-*YYYY-MM-DD-HHMMSS*.TXT is used (where *YYYY-MM-DD* represents the current date and *HHMMSS* represents the current time).

6. (Optional) Log to an SNMP management station.

   a. Configure a destination for SNMP traps:

FWSM 2.x	`Firewall(config)# snmp-server host [if_name] ip_addr trap`
PIX 6.x	`Firewall(config)# snmp-server host [if_name] ip_addr trap`
PIX 7.x	`Firewall(config)# snmp-server host if_name ip_addr trap [community string] [version version] [udp-port port]`

   The SNMP management station is located on the firewall interface named *if_name* (**inside**, for example) at IP address *ip_addr*.

   b. Enable traps to be sent by SNMP:

FWSM 2.x	`Firewall(config)# snmp-server enable traps {all ¦ syslog}`
PIX 6.x	`Firewall(config)# snmp-server enable traps`
PIX 7.x	`Firewall(config)# snmp-server enable traps {all ¦ syslog}`

   By default, all trap types are sent. PIX 7.x allows specific types of traps to be sent, as described in Chapter 4, "Firewall Management," in section 4-6, "Monitoring a Firewall with SNMP." Only the **all** and **syslog** trap types are shown here, because either is sufficient for the purpose of sending Syslog messages as SNMP traps.

c. Enable traps containing logging messages to be sent:

FWSM 2.x	`Firewall(config)# logging history level`
PIX 6.x	`Firewall(config)# logging history level`
PIX 7.x	`Firewall(config)# logging history {level ¦ event-list}`

Logging messages can be sent as SNMP traps to any configured SNMP management station. Messages are sent if they are at or below the specified severity *level*: **emergencies** (**0**), **alerts** (**1**), **critical** (**2**), **errors** (**3**), **warnings** (**4**), **notifications** (**5**), **informational** (**6**), or **debugging** (**7**). Each message is sent in a separate SNMP trap packet.

With PIX 7.x, you can also use a policy to select which messages are displayed. Messages that are matched by the event list named *event-list* (defined in Step 2) are forwarded to the logging destination.

7. (Optional) Log to a Syslog server.

a. Set the logging level:

FWSM 2.x	`Firewall(config)# logging trap level`
PIX 6.x	`Firewall(config)# logging trap level`
PIX 7.x	`Firewall(config)# logging trap {level ¦ event-list}`

Messages are sent to any configured Syslog servers if they are at or below the specified severity *level*: **emergencies** (**0**), **alerts** (**1**), **critical** (**2**), **errors** (**3**), **warnings** (**4**), **notifications** (**5**), **informational** (**6**), or **debugging** (**7**).

With PIX 7.x, you can also use a policy to select which messages are displayed. Messages that are matched by the event list named *event-list* (defined in Step 2) are forwarded to the logging destination.

NOTE You might find it confusing that logging messages sent as SNMP traps are configured using **logging history** and messages sent as Syslog packets are configured using **logging trap**. Unfortunately, the term "trap" has a different meaning here.

b. (Optional) Identify the firewall in Syslog messages:

FWSM 2.x	`Firewall(config)# logging device-id {context-name ¦ hostname ¦ ipaddress if_name ¦ string text}`
PIX 6.x	`Firewall(config)# logging device-id {hostname ¦ ipaddress if_name ¦ string text}`

PIX 7.x	`Firewall(config)# logging device-id {context-name ¦ hostname ¦ ipaddress if_name ¦ string text}`

A Syslog server usually records the originating IP address along with each message received. However, you can define one unique identifier for your firewall that also appears in the text of each Syslog message. (This identifier does not appear in EMBLEM formatted messages.)

The identifier can be the firewall's host name (defined with the **hostname** configuration command), the IP address of a specific firewall interface named *if_name* ("inside" or "outside," for example), or an arbitrary *text* string (up to 16 characters). With PIX 7.x or FWSM 2.x operating in multiple-context mode, the name of the firewall context can also be sent.

For example, the following firewall is named InnerSanctum. It identifies itself using its host name:

```
Firewall(config)# hostname InnerSanctum
Firewall(config)# logging device-id hostname
```

c. Identify a Syslog server destination:

FWSM 2.x	`Firewall(config)# logging host [if_name] ip_address [protocol/port] [format emblem] [interface if1 [if2] ...]`
PIX 6.x	`Firewall(config)# logging host if_name ip_address [protocol/port] [format emblem]`
PIX 7.x	`Firewall(config)# logging host if_name ip_address [protocol/port] [format emblem]`

Syslog messages are sent out the firewall interface named *if_name* ("inside" or "outside," for example) to the Syslog server located at IP address *ip_address*. By default, messages are sent using UDP port 514. You can specify either UDP or TCP with *protocol* (**udp** or IP protocol **17**, or **tcp** or IP protocol **6**) and *port* (1025 to 65535). Obviously, the Syslog server must be configured to listen on the matching protocol and port number.

You can use the **format emblem** keywords to send logging messages in the EMBLEM format.

The firewall in the following example sends its trap logging messages to the Syslog server using the default UDP port 514:

```
Firewall(config)# logging host inside 192.168.199.70
```

This command can be repeated to define multiple Syslog servers.

NOTE Keep in mind that the firewall sends a copy of each Syslog message generated to each of the configured Syslog servers. If your firewall is heavily utilized and is configured to generate high-severity messages to multiple Syslog servers, its performance can be affected.

Normally, Syslog messages are sent using UDP port 514. This provides an easy way to send messages in a best-effort fashion. The firewall has no idea if the messages are being received by the Syslog server, much less if there is actually a Syslog server at the address.

Some environments require strict collection of security information. In this case, you should use TCP to send Syslog messages, usually over port 1470. The firewall opens a TCP connection with the Syslog server. As long as the connection is open, the firewall is certain that the messages are being reliably received.

In fact, the TCP Syslog method is designed to be so reliable that the connection closes if the Syslog server becomes unavailable or if its logging storage becomes full. At this point, the firewall immediately stops forwarding traffic and generates a "201008: The PIX is disallowing new connections" message. You can also see this with the **show logging** command, as in the following example. Notice that TCP Syslog is still configured to use the Syslog server but is shown as disabled:

```
Firewall# show logging
Syslog logging: enabled
    Facility: 20
    Timestamp logging: enabled
    Standby logging: disabled
    Console logging: disabled
    Monitor logging: disabled
    Buffer logging: level informational, 716 messages logged
    Trap logging: level informational, 162 messages logged
        Logging to inside 172.21.4.1 tcp/1470 disabled
    History logging: disabled
    Device ID: hostname "Firewall"
```

If this condition occurs, check the Syslog server and determine the source of the problem. After the Syslog service is restored, you have to reconfigure the TCP Syslog connection manually by entering the **logging host** *if_name ip_address* **tcp**/*port* configuration command.

TIP With PIX 7.x, you can use the following command to allow firewall operation to continue, even if a TCP Syslog server is down:

```
Firewall(config)# logging permit-hostdown
```

d. (Optional) Tune the Syslog transmission queue.

As Syslog messages are generated, they are placed in a queue for transmission. If messages are being generated faster than they can be sent, the logging queue begins to fill. By default, a firewall queues up to 512 messages. As soon as this threshold is reached, any new messages are simply dropped and are not sent.

You can see information about the logging queue with the following EXEC command:

```
Firewall# show logging queue
```

The output from this command displays the size of the queue, along with the current queue depth and the high-water mark. If the **msgs most on queue** value is 512, the queue filled up at some point, and messages have been lost. In the following example, a high volume of logging messages is being generated, but they are being transmitted fast enough that the queue has never filled.

```
Firewall# show logging queue
        Logging Queue length limit : 512 msg(s)
        Current 0 msg on queue, 136 msgs most on queue
Firewall#
```

If you find that the logging queue is consistently full ("512 msgs most on queue"), you can tune the queue's size. Use the following configuration command:

```
Firewall(config)# logging queue queue_size
```

The queue holds *queue_size* messages (0 to 8192; 0 = unlimited up to available memory). You can use the **show blocks** EXEC command to see how much memory is available before tuning the queue. Syslog messages use 256-byte blocks of memory. Be careful not to allocate too much of this memory to the logging queue, because the 256-byte blocks are also used for stateful failover message queuing.

e. (Optional) Add time stamps to Syslog messages:

```
Firewall(config)# logging timestamp
```

By default, Syslog messages are sent with no indication of the date or time at which they occurred. In this case, the Syslog server should add its own time stamps to the messages as they are received. Make sure the Syslog server synchronizes its clock with a known and accurate source.

The **logging timestamp** command causes the firewall to add a time stamp to each Syslog message before it is sent. The firewall should have its clock set and time synchronized to a known and accurate source—preferably an NTP server that is common to all devices on your network.

TIP If the **logging timestamp** command is used to make the firewall add time stamps, it is also possible that the Syslog server is configured to add its own time stamps. This can result in logging messages that have double time stamps in the text. Many Syslog servers can be configured to detect this and strip the extra time stamp automatically.

f. (Optional) Set the Syslog facility:

```
Firewall(config)# logging facility facility
```

Syslog servers can collect logging messages from a variety of sources. Messages are marked with a *facility* number (0 to 23), allowing the Syslog server to classify and store messages from similar sources.

Facility numbers correspond to the UNIX-based Syslog facility names as follows: 0 (Kern), 1 (User), 2 (Mail), 3 (Daemon), 4 (Auth), 5 (Syslog), 6 (Lpr), 7 (News), 8 (UUCP), 9 (Cron), 10 to 15 (System0 to System5), 16 to 23 (Local0 to Local7).

The default facility, 20, is also known as the Local4 facility. This is usually expected by most Syslog server implementations.

g. (Optional) Generate Syslog messages from the standby failover unit:

```
Firewall(config)# logging standby
```

Normally, only the active firewall unit in an active/passive failover pair generates Syslog messages. If your environment needs strict collection of logging information, you can use this command to cause the standby firewall to generate Syslog messages too.

The standby firewall can generate the same Syslog messages as the active unit only because the same state information is passed from the active unit to the passive unit. This doubles the number of messages sent to the Syslog server(s), and each message is duplicated. However, if the active unit fails, any messages that were queued might be lost. The standby unit continues sending those messages as if nothing happened.

8. (Optional) Log to an e-mail address.

When logging messages are generated, they can be sent to an e-mail address. Each message is sent as a single e-mail message. You can configure the "From" and "To" addresses for the resulting e-mails. The firewall always sends these with the subject line "PIX Alert (*hostname*)." The actual e-mail message has the following format:

```
Date: Tue, 3 May 2005 16:17:43 Eastern
From: pix@mycompany.com
To: hucaby@mycompany.com
Subject: PIX Alert (Firewall-c)
May 03 2005 16:17:43  admin : %PIX-2-106001: Inbound TCP connection
```

```
denied from 172.16.89.4/1489 to 172.21.2.200/23 flags INVALID on
interface outside
```

In this example, the firewall has added its own time stamp and the originating context name (admin in multiple-context mode) to the logging message text.

a. Set the mail logging level:

FWSM 2.x	—
PIX 6.x	—
PIX 7.x	`Firewall(config)# logging mail {level ¦ event-list}`

Messages are sent to any configured e-mail recipient addresses if they are at or below the specified severity *level*: **emergencies** (**0**), **alerts** (**1**), **critical** (**2**), **errors** (**3**), **warnings** (**4**), **notifications** (**5**), **informational** (**6**), or **debugging** (**7**). PIX 7.x also lets you use a policy to select which messages are sent. Messages that are matched by the event list named *event-list* (defined in Step 2) are forwarded to the logging destination.

b. Identify an SMTP server for e-mail delivery:

FWSM 2.x	—
PIX 6.x	—
PIX 7.x	`Firewall(config)# smtp-server server_primary [server_secondary]`

The firewall sends all its mail logging messages to an SMTP server, which should relay the mail to the appropriate recipients. Up to two servers can be identified, either by IP address or host name. The firewall first tries to send to *server_primary*. If that fails, it tries *server_secondary*.

NOTE If you use a host name, a matching **name** command must already be configured so that the name can be resolved to an IP address. This is because the firewall won't resolve names through an external DNS server. Instead, resolution must happen internally.

Even if you supply a host name with the **smtp-server** command, the IP address is substituted in the actual running-config.

c. Assign a source address for the messages:

FWSM 2.x	—
PIX 6.x	—
PIX 7.x	`Firewall(config)# logging from-address from_email_address`

Mail messages are sent with an arbitrary e-mail source address of *from_email_address*. This address is not automatically verified or resolved; instead, it is just copied into the resulting message and sent to the SMTP server. The address can be fictitious, because it isn't necessary or possible to reply to that address. In the following sample command, logging messages appear to be sent from mypix@mycompany.com:

```
Firewall(config)# logging from-address mypix@mycompany.com
```

d. Identify the e-mail recipient:

FWSM 2.x	—
PIX 6.x	—
PIX 7.x	`Firewall(config)# logging recipient-address` *to_email_address* `[level` *level*`]`

Logging messages are sent to the recipient address *to_email_address*. This can be an actual person's address or the address of a system that can automatically distribute the e-mail message to any number of recipients. You can repeat this command to define multiple recipient addresses.

Each mail logging recipient can have a unique severity level associated with it, specified as *level*: **emergencies** (**0**), **alerts** (**1**), **critical** (**2**), **errors** (**3**), **warnings** (**4**), **notifications** (**5**), **informational** (**6**), or **debugging** (**7**). If a message is at or below the recipient's severity level, it is sent. However, the **logging mail** *level* command sets the highest possible severity that can be sent to any e-mail recipient.

CAUTION Be careful when you set a mail logging severity level. Remember that *each* relevant logging message is sent as a separate e-mail message. A highly utilized firewall or a severity level that is too great can quickly overload a recipient's mailbox. In addition, it can overload the firewall's SMTP queue to the point that new logging messages are dropped. The firewall reminds you of this potential, as the following example demonstrates:

```
pix/admin(config)# logging recipient-address hucaby@mycompany.com level
  informational
WARNING: SMTP logging is very inefficient.  At this severity level,
         a large number of syslogs might overwhelm the SMTP
         input queue, resulting in dropped messages.
pix/admin(config)#
```

9. (Optional) Allow logging to an ASDM management application.

   A firewall can feed logging messages to one or more ASDM sessions. Messages are kept in a buffer until they are requested by an ASDM session. The messages are transferred to ASDM over an SSL connection rather than as traditional Syslog packets.

   a. (Optional) Set the buffer size for ASDM messages:

FWSM 2.x	—
PIX 6.x	—
PIX 7.x	`Firewall(config)# logging asdm-buffer-size num_of_msgs`

   By default, the buffer holds 100 messages. You can adjust the buffer size to *num_of_msgs* (100 to 512 messages).

   b. Set the PDM logging level:

FWSM 2.x	—
PIX 6.x	—
PIX 7.x	`Firewall(config)# logging asdm {level ¦ event-list}`

   Messages are buffered for ASDM if they are at or below the specified severity *level*: **emergencies** (**0**), **alerts** (**1**), **critical** (**2**), **errors** (**3**), **warnings** (**4**), **notifications** (**5**), **informational** (**6**), or **debugging** (**7**).

   Beginning in PIX 7.x, you can also use a policy to select which messages are displayed. Messages that are matched by the event list named *event-list* (defined in Step 2) are buffered for ASDM use.

Verifying Message Logging Activity

Use the **show logging** command to verify where logging messages are being sent. The first few lines of output display message counters for every possible logging destination.

The firewall in the following example has sent 117 messages to the console, 408,218 messages to the internal buffer (only 4096 bytes of the most recent messages are kept), and 1,852,197 messages to the Syslog host at 192.168.199.200. You can also verify each destination's severity level.

```
Firewall# show logging
Syslog logging: enabled
    Facility: 20
    Timestamp logging: enabled
    Standby logging: disabled
    Console logging: level warnings, 117 messages logged
    Monitor logging: level errors, 0 messages logged
    Buffer logging: level informational, 408218 messages logged
    Trap logging: level informational, 1852197 messages logged
```

```
        Logging to outside 192.168.199.200
    History logging: disabled
    Device ID: hostname "Firewall"
```

PIX 7.x provides some additional information, along with the settings of its additional logging destinations. The **show logging setting** command displays the same type of information without showing the logging buffer contents, as demonstrated in the following example:

```
Firewall/admin# show logging setting
Syslog logging: enabled
    Facility: 20
    Timestamp logging: enabled
    Standby logging: disabled
    Deny Conn when Queue Full: disabled
    Console logging: disabled
    Monitor logging: disabled
    Buffer logging: list MyFilter, class config ip np session sys, 6756 messages
  logged
    Trap logging: level debugging, facility 20, 259799 messages logged
        Logging to outside syslog.mycompany.com
    History logging: disabled
    Device ID: context name "admin"
    Mail logging: level critical, 166 messages logged
    ASDM logging: level informational, 246891 messages logged
Firewall/admin#
```

PIX 7.x lets you add message filters and classes to any logging destination. The preceding example shows how an event list called **MyFilter** is being used on the logging buffer. Buffered logging also is being performed for the event classes called **config**, **ip**, **np**, **session**, and **sys**.

Notice that the firewall is using its context name as a device ID. Settings and counters are also shown for mail logging and PDM logging.

Manually Testing Logging Message Generation

If it isn't apparent that the firewall is sending Syslog messages, you can use another method to force messages to be sent while watching them being received at the destination. First, make sure the logging destination has been configured for severity level 4 or greater. Then, from enable mode in a session, run the following EXEC commands with a bogus or unused IP address:

```
Firewall# shun ip-address
Firewall# no shun ip-address
```

This creates and deletes a temporary shun on the nonexistent address. This command is handy because it is the only one that generates simple Syslog messages at a very low severity level (level 4, warnings) without a complex scenario. You should see the following logging messages displayed at the appropriate logging destination:

```
401002: Shun added: 10.1.1.1 0.0.0.0 0 0
401003: Shun deleted: 10.1.1.1
```

TIP You can view the firewall's internal logging buffer with the **show logging** EXEC command. Only the most recent messages still remaining in the buffer are shown. As in the preceding shun example, notice that time stamps and the **%PIX**-*severity-messageID* prefix are not added to the buffered messages in PIX 6.3. Only the six-digit message number and the message text are kept. PIX 7.x adds both time stamps (if configured to do so) and the complete **%PIX**-*severity-messageID* prefix to each message in the buffer.

To clear the internal logging buffer, you can use the **clear logging** (PIX 6.3) or **clear logging buffer** (PIX 7.x) command.

9-3: Fine-Tuning Logging Message Generation

After you have chosen and configured severity levels for logging destinations, you should make sure you are receiving only necessary messages. In other words, don't choose a severity level that can produce an abundance of messages that will be ignored. Always keep in mind that a Syslog server must receive and archive every message sent to it. Storage space is at a premium, especially when logs continuously grow over time.

Here are rules of thumb to follow when choosing a severity level:

- If only firewall error conditions should be recorded and no one will regularly view the message logs, choose severity level 3 (errors).
- If you are primarily interested in seeing how traffic is being filtered by the firewall access lists, choose severity level 4 (warnings).
- If you need an audit trail of firewall users and their activity, choose severity level 5 (notifications).
- If you will be using a firewall log analysis application, you should choose severity level 6 (informational). This is the only level that produces messages about connections that are created, as well as the time and data volume usage.
- If you need to use any **debug** command to troubleshoot something on the firewall, choose a destination with severity level 7 (debugging). You can use the **logging debug-trace** command to force debug output to be sent to a logging destination for later review. All Syslog messages containing debug output use message ID 711001 at a default severity level of 7.

Pruning Messages

If you find that a severity level meets your needs but generates some unnecessary messages, you can "prune" those messages and keep them from being generated at all. Locate the message from an actual Syslog capture, from the lists of messages in this section, or from the message listing in

Appendix B, "Security Appliance Logging Messages". Next, disable the message based on its six-digit message number with the following configuration command:

```
Firewall(config)# no logging message message-number
```

You can see a listing of all the disabled logging messages with the following EXEC command:

```
Firewall# show logging message
```

To re-enable a disabled message, you can use the **logging message** *message-number* configuration command. In PIX 7.x, to return all messages to their default levels, you can use the **clear configure logging disabled** configuration command.

Changing the Message Severity Level

Recall that each logging message has a default severity level associated with it. You can change that default behavior so that a message is sent based on a configurable severity level instead. This might be useful if you choose a severity level for a logging destination that includes most (but not all) of the messages that are interesting to you. For the messages that have a higher default level and that will not be sent, you can reconfigure their level to a lower value.

To change a message's severity level, use the following configuration command:

```
Firewall(config)# logging message message-number [level level]
```

Here, the message is identified by its six-digit *message-number* or Syslog ID and is assigned a new severity *level* (0 to 7). To see a message's current severity level, you can use the following EXEC command:

```
Firewall# show logging message {message-number ¦ all}
```

The **all** keyword causes the state of all known or supported logging messages to be listed. Otherwise, you can specify the six-digit *message-number* to see the state of a specific message. The output shows the default severity level, the newly configured severity level (if any), and whether the message is enabled.

For example, suppose a firewall administrator wants to completely disable Syslog message 111008 while changing the severity of message 111009 from its default (debugging) to notifications. You could use the following commands to accomplish and verify this:

```
Firewall/admin(config)# logging message 111009 level notifications
Firewall/admin(config)# no logging message 111008
Firewall/admin(config)# exit
Firewall/admin# show logging message
syslog 111009: default-level debugging, current-level notifications (enabled)
syslog 111008: default-level notifications (disabled)
Firewall/admin#
```

Access List Activity Logging

By default, logging message 106023 (default severity level 4, warnings) is generated when a **deny** access list entry is matched with a traffic flow. Only the overall ACL is listed in the message, with no reference to the actual denying ACL entry, as in the following example:

```
%PIX-4-106023: Deny tcp src outside:220.163.33.180/18909 dst inside:
  10.10.95.23/8039 by access-group "acl_outside"
```

You can log messages when specific access control entries (ACEs, or individual permit/deny statements within an ACL) permit or deny a traffic flow by adding the **log** keyword to an ACE.

You can also log the rate at which traffic flows match specific access list entries. This can be useful to gauge the volume of attacks or exploits that are occurring over time.

After a traffic flow triggers an ACE configured for logging, the firewall keeps the flow in a cached list. If the reporting interval completes and there are no additional occurrences of the same flow, the cached entry is deleted, and the flow's hit count becomes 0.

You can set the logging severity level on a per-ACE basis if needed. Otherwise, severity level 6 is the default.

TIP ACE logging generates logging message 106100 (default severity level 6), which has the following format:

```
%PIX-6-106100: access-list acl_ID {permitted ¦ denied ¦ est-allowed}
  protocol interface_name/source_address(source_port) ->
  interface_name/dest_address(dest_port) hit-cnt number ({first hit ¦
  number-second interval})
```

The ACL name *acl_ID* is shown to have permitted or denied a traffic flow. The specific traffic flow is defined as a *protocol* (UDP or TCP, for example), from the source (firewall interface name, IP address, and port) to the destination (firewall interface name, IP address, and port).

If this is the first packet in a flow, the hit count is 1, followed by the "first hit" flag. If the traffic flow has already been seen and is being tracked, this logging message appears at intervals defined along with the ACE **log** keyword. The hit count reflects how many times the same flow has been attempted, and the hit count interval is shown as a *number* of seconds. Using the hit count and interval timing values allows you to calculate the flow rate that is occurring.

1. Configure logging on specific access list entries:

FWSM 2.x	`Firewall(config)# access-list acl_name [extended] {permit ¦ deny} ... log [level] [interval seconds]`
PIX 6.x	`Firewall(config)# access-list acl_name {permit ¦ deny} ... log [level] [interval seconds]`
PIX 7.x	`Firewall(config)# access-list acl_name [extended] {permit ¦ deny} ... log [level] [interval seconds]`

Enter the access list entry normally, but add the **log** keyword at the end. If you want to log activity on this entry at a severity level other than 6, specify the *level* (1 to 7) too.

As soon as a traffic flow triggers this ACE, the hit count begins to increment with each new occurrence of the same flow. Nonzero hit counts are reported with a logging message at intervals of *seconds* (1 to 600; the default is 300 seconds or 5 minutes).

TIP If you already have an access list configured and in place on a firewall, you can safely add the logging capability to any number of ACEs within it. In other words, when **log** and its associated fields are added to an existing ACE, the ACE remains in its current location in the list sequence; it isn't moved to the end of the list. In addition, you don't have to remove the ACE before configuring the **log** options. Simply re-enter the existing ACE and add the **log** keyword and options.

In the following example, an existing ACL called acl_out is being used on a production firewall. The third ACE needs to have logging added to it at severity level 4. Notice that after the ACE command is re-entered with **log 4** added, it stays in the third ACE position and becomes active immediately.

```
Firewall# show running-config
[output omitted]
access-list acl_out permit icmp any any
access-list acl_out permit tcp any host 192.168.199.100 eq telnet
access-list acl_out permit tcp any host 192.168.199.100 eq www
access-list acl_out permit icmp any host 192.168.199.100
[output omitted]
Firewall(config)# access-list acl_out permit tcp any host 192.168.199.100
  eq www log 4
Firewall# show running-config
[output omitted]
access-list acl_out permit icmp any any
access-list acl_out permit tcp any host 192.168.199.100 eq telnet
access-list acl_out permit tcp any host 192.168.199.100 eq www log 4
access-list acl_out permit icmp any host 192.168.199.100
[output omitted]
```

To disable message ID 106100 logging on an ACE, re-enter the command with the **log default** keywords appended. For example, the preceding shaded command would be re-entered as

```
Firewall(config)# access-list acl_out permit tcp any host 192.168.199.100
  eq www log default
```

You can also re-enter the ACE with the **log disable** keywords to completely disable all ACE logging (both message IDs 106100 and 106023). In this case, the sample command would be re-entered as

```
Firewall(config)# access-list acl_out permit tcp any host 192.168.199.100
  eq www log disable
```

2. Limit the volume of deny messages.

   a. Limit the number of deny flows that are tracked:

   ```
   Firewall(config)# access-list deny-flow-max n
   ```

   Each unique traffic flow that is denied by an ACE configured for logging is added to a cached list of tracked flows. This usually isn't a problem unless something like a denial-of-service attack causes a very large number of flows to be denied and tracked.

   The firewall limits the maximum number of denied flows it tracks. By default, the maximum number is based on the available firewall memory: 4096 (64 MB or more), 1024 (16 MB or more), or 256 (less than 16 MB).

   You can change this to a lower maximum number of flows by specifying *n* (1 to the default maximum).

   b. (Optional) Send an alert when the number of tracked flows is too high:

   ```
   Firewall(config)# access-list alert-interval seconds
   ```

   When the maximum number of tracked flows is reached, the firewall generates logging message 106101. By default, this message is limited to appearing only every 300 seconds (5 minutes). You can change the alert interval to *seconds* (1 to 3600 seconds).

9-4: Analyzing Firewall Logs

The most important thing you can do with a firewall is collect and analyze its Syslog information.

Firewall logs should be inspected on a regular basis. Always make sure the Syslog collector or server is configured to archive older information and that disk space is not completely consumed.

The Syslog collector or server should be sized according to the following parameters:

- The number of firewalls and other network devices sending Syslog messages to the Syslog server
- The number of Syslog events per second (usually called EPS) generated by all devices

- How long Syslog information should be kept available

Consider the type of information you want to get from your firewall logs. Here are some examples:

- **Connections permitted by firewall rules**—Glancing through these messages can help you spot "holes" that remain open in your security policies.
- **Connections denied by firewall rules**—You can instantly see what types of activity are being directed toward your secured inside network.
- **Denied rule rates**—Using the ACE deny rate logging feature can show attacks that are occurring against your firewall.
- **User activity**—Firewall user authentication and command usage can all be logged, providing an audit trail of security policy changes.
- **Cut-through-proxy activity**—As end users authenticate and pass through the firewall, their activity can be logged for a general audit trail.
- **Bandwidth usage**—Firewall logs can show each connection that was built and torn down, as well as the duration and traffic volume used. This can be broken down by connection, user, department, and so on.
- **Protocol usage**—Firewall logs can show the protocols and port numbers that are used for each connection.
- **Intrusion Detection System (IDS) activity**—A firewall can be configured with a set of IDS signatures and can log attacks that occur.
- **Address translation audit trail**—If Network Address Translation (NAT) or Port Address Translation (PAT) is being used, the firewall logs can keep records of each translation that is built or torn down. This can be useful if you receive a report of malicious activity coming from inside your network toward the outside world. You can backtrack to find which internal user had a specific global IP address at a specific time.

You can scan the flat or raw Syslog data yourself to discover quite a few curious events or trends. However, if your firewall generates a large amount of logging information, you might want to invest in a firewall log analysis tool.

You should choose a logging analysis application that is tailored for firewalls so that the connection and ACL messages (among many others) can be fully utilized. The following are some firewall logging analysis applications:

- CS-MARS from Cisco Systems (http://www.cisco.com)
- Network Intelligence Engine from Network Intelligence (http://www.network-intelligence.com)
- Network Security Analyzer and FirewallAnalyzer Enterprise from eIQnetworks (http://www.eiqnetworks.com)
- Sawmill Log Analyzer from FlowerFire (http://www.sawmill.net)

- CiscoWorks VPN and Security Management Solution (VMS) and Security Information Management Solution (SIMS) from Cisco Systems (http://www.cisco.com)

Consider the volume of Syslog information your firewalls and other network devices will generate. Syslog collection and analysis tools must be able to handle a sustained number of events per second so that no logging information is missed. They must also be able to store Syslog data over a reasonable period of time so that you can come back and analyze information from the recent past.

You can get an idea of how many events per second a firewall generates without having a Syslog collector already in place. You can use the firewall's internal logging buffer as a gauge. Follow these steps:

1. Enable logging to the buffer at a severity level:

   ```
   Firewall(config)# logging buffered level
   ```

   Here, the severity level is set to *level* (0 to 7): **emergencies** (**0**), **alerts** (**1**), **critical** (**2**), **errors** (**3**), **warnings** (**4**), **notifications** (**5**), **informational** (**6**), or **debugging** (**7**). The higher the level, the more messages (and types of messages) that are generated.

   Set this to the level you think will generate the logging messages you are most interested in recording. When this command is executed, logging to the buffer begins immediately.

2. Read the logging buffer counter as a baseline:

   ```
   Firewall# show logging
   ```

   Note when you issue this command. This begins the time period during which buffered logging is monitored.

   The "*n* messages logged" counters can't be reset while the firewall is operational. Therefore, you can take a reading of the buffer logging message counter now as a starting point. The logging counters are shown in the first few lines of output. For PIX 7.x, you can use the **show logging setting** command to omit any output except settings and counters.

   In the following example, the firewall begins with 460,864 messages that have already been sent to the buffer, because buffered logging has been active in the past.

   ```
   Firewall# show logging
   Syslog logging: enabled
       Facility: 20
       Timestamp logging: disabled
       Standby logging: disabled
       Console logging: disabled
       Monitor logging: disabled
       Buffer logging: level informational, 460864 messages logged
       Trap logging: level warnings, 1882119 messages logged
           Logging to outside 192.168.254.100
       History logging: disabled
       Device ID: disabled
   ```

3. Wait 1 minute and then see how many messages were sent to the buffer:

   ```
   Firewall# show logging
   ```

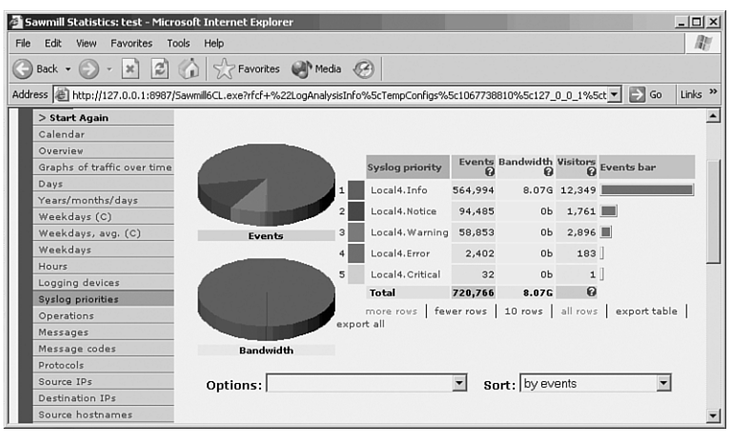
Note the number of buffer messages logged now, and calculate the difference between this and the baseline number from Step 2. This is the number of messages generated at the desired severity level over the span of 60 seconds. Divide that by 60, and you have an estimate of events or messages per second (EPS).

In the following example, the firewall begins with 438,113 buffered messages. After 1 minute of buffered logging at severity level 6 (informational), the counter has risen to 460,864. 460,864 minus 438,113 equals 22,751 messages in one minute, or 379 messages per second.

```
Firewall# config term
Firewall(config)# logging buffered informational
Firewall(config)# exit
Firewall# show logging
Syslog logging: enabled
    Facility: 20
    Timestamp logging: disabled
    Standby logging: disabled
    Console logging: disabled
    Monitor logging: disabled
    Buffer logging: level warnings, 438113 messages logged
    Trap logging: level warnings, 1882092 messages logged
        Logging to outside 192.168.254.100
    History logging: disabled
    Device ID: disabled
 [after one minute]
Firewall# show logging
Syslog logging: enabled
    Facility: 20
    Timestamp logging: disabled
    Standby logging: disabled
    Console logging: disabled
    Monitor logging: disabled
    Buffer logging: level informational, 460864 messages logged
    Trap logging: level warnings, 1882119 messages logged
        Logging to outside 192.168.254.100
    History logging: disabled
    Device ID: disabled
```

As you might expect, higher severity levels generate more logging messages. This is because the firewall reports on more types of normal activity. Higher severity levels actually mean that the events reported are less severe (more normal). Figure 9-3 shows a sample breakdown of the Syslog severity levels in messages that were collected over an hour from a firewall supporting an enterprise of several thousand users. Notice how the number of Local4.Critical (level 2) messages are few, progressing to the very large number of Local4.Info (level 6) messages.

Figure 9-3 *Sample Breakdown of Received Syslog Messages by Severity Level*



Section 9-4