PIDAS Fencing

Perimeter Intrusion Detection and Assessment System (PIDAS) is a type of fencing that has sensors located on the wire mesh and at the base of the fence. It is used to detect if someone attempts to cut or climb the fence. It has a passive cable vibration sensor that sets off an alarm if an intrusion is detected. PIDAS is very sensitive and can cause many false alarms.

The posts should be buried sufficiently deep in the ground and should be secured with concrete to ensure they cannot be dug up or tied to vehicles and extracted. If the ground is soft or uneven, this might provide ways for intruders to slip or dig under the fence. In these situations, the fencing should actually extend into the dirt to thwart these types of attacks.

Fences work as "first line of defense" mechanisms. A few other controls can be used also. Strong and secure gates need to be implemented. It does no good to install a highly fortified and expensive fence and then have an unlocked or flimsy gate that allows easy access.

Gates basically have four distinct classifications:

- **Class I** Residential usage
- **Class II** Commercial usage, where general public access is expected; examples include a public parking lot entrance, a gated community, or a self-storage facility
- **Class III** Industrial usage, where limited access is expected; an example is a warehouse property entrance not intended to serve the general public
- **Class IV** Restricted access; this includes a prison entrance that is monitored either in person or via closed circuitry

Each gate classification has its own long list of implementation and maintenance guidelines to ensure the necessary level of protection. These classifications and guidelines are developed by UL (formerly Underwriters Laboratory), a nonprofit organization that tests, inspects, and classifies electronic devices, fire protection equipment, and specific construction materials. This is the group that certifies these different items to ensure they are in compliance with national building codes. A specific UL code, UL 325, deals with garage doors, drapery, gates, and louver and window operators and systems.

So, whereas in the information security world we look to NIST for our best practices and industry standards, in the physical security world, we look to UL for the same type of direction.

Bollards

Bollards usually look like small concrete pillars outside a building. Sometimes companies try to dress them up by putting flowers or lights in them to soften the look of a protected environment. They are placed by the sides of buildings that have the most immediate threat of someone driving a vehicle through the exterior wall. They are usually placed

between the facility and a parking lot and/or between the facility and a road that runs close to an exterior wall. An alternative, particularly in more rural environments, is to use very large boulders to surround and protect sensitive sites. They provide the same type of protection that bollards provide.

Lighting

Many of the items mentioned in this chapter are things people take for granted day in and day out during our usual busy lives. Lighting is certainly one of those items you probably wouldn't give much thought to, unless it wasn't there. Unlit (or improperly lit) parking lots and parking garages have invited many attackers to carry out criminal activity that they may not have engaged in otherwise with proper lighting. Breaking into cars, stealing cars, and attacking employees as they leave the office are the more common types of attacks that take place in such situations. A security professional should understand that the right illumination needs to be in place, that no dead spots (unlit areas) should exist between the lights, and that all areas where individuals may walk should be properly lit. A security professional should also understand the various types of lighting available and where they should be used.

Wherever an array of lights is used, each light covers its own zone or area. The size of the zone each light covers depends on the illumination of light produced, which usually has a direct relationship to the wattage capacity of the bulbs. In most cases, the higher the lamp's wattage, the more illumination it produces. It is important that the zones of illumination coverage overlap. For example, if a company has an open parking lot, then light poles must be positioned within the correct distance of each other to eliminate any dead spots. If the lamps that will be used provide a 30-foot radius of illumination, then the light poles should be erected less than 30 feet apart so there is an overlap between the areas of illumination.

NOTE Critical areas need to have illumination that reaches at least eight feet with the illumination of two foot-candles. Foot-candle is a unit of measure of the intensity of light.

If an organization does not implement the right types of lights and ensure they provide proper coverage, the probability of criminal activity, accidents, and lawsuits increases.

Exterior lights that provide protection usually require less illumination intensity than interior working lighting, except for areas that require security personnel to inspect identification credentials for authorization. It is also important to have the correct lighting when using various types of surveillance equipment. The correct contrast between a potential intruder and background items needs to be provided, which only happens with the correct illumination and placement of lights. If the light is going to bounce off of dark, dirty, or darkly painted surfaces, then more illumination is required for the necessary contrast between people and the environment. If the area has clean concrete and light-colored painted surfaces, then not as much illumination is required. This is because when the same amount of light falls on an object and the surrounding background, an observer must depend on the contrast to tell them apart.

When lighting is installed, it should be directed toward areas where potential intruders would most likely be coming from and directed away from the security force posts. For example, lighting should be pointed at gates or exterior access points, and the guard locations should be more in the shadows, or under a lower amount of illumination. This is referred to as *glare protection* for the security force. If you are familiar with military operations, you might know that when you are approaching a military entry point, there is a fortified guard building with lights pointing toward the oncoming cars. A large sign instructs you to turn off your headlights, so the guards are not temporarily blinded by your lights and have a clear view of anything coming their way.

Lights used within the organization's security perimeter should be directed outward, which keeps the security personnel in relative darkness and allows them to easily view intruders beyond the organization's perimeter.

An array of lights that provides an even amount of illumination across an area is usually referred to as *continuous lighting*. Examples are the evenly spaced light poles in a parking lot, light fixtures that run across the outside of a building, or a series of fluorescent lights used in parking garages. If an organization's building is relatively close to someone else's developed property, a railway, an airport, or a highway, the organization may need to ensure the lighting does not "bleed over" property lines in an obtrusive manner. Thus, the illumination needs to be *controlled*, which just means the organization should erect lights and use illumination in such a way that it does not blind its neighbors or any passing cars, trains, or planes.

You probably are familiar with the special home lighting gadgets that turn certain lights on and off at predetermined times, giving the illusion to potential burglars that a house is occupied even when the residents are away. Organizations can use a similar technology, which is referred to as *standby lighting*. The security personnel can configure the times that different lights turn on and off, so potential intruders think different areas of the facility are populated.

NOTE Redundant or backup lights should be available in case of power failures or emergencies. Special care must be given to understand what type of lighting is needed in different parts of the facility in these types of situations. This lighting may run on generators or battery packs.

Responsive area illumination takes place when an IDS detects suspicious activities and turns on the lights within a specific area. When this type of technology is plugged into automated IDS products, there is a high likelihood of false alarms. Instead of continually having to dispatch a security guard to check out these issues, an organization can install a CCTV camera (described in the upcoming section "Visual Recording Devices") to scan the area for intruders.

If intruders want to disrupt the security personnel or decrease the probability of being seen while attempting to enter an organization's premises or building, they could attempt to turn off the lights or cut power to them. This is why lighting controls and switches should be in protected, locked, and centralized areas.

Surveillance Devices

Usually, installing fences and lights does not provide the necessary level of protection an organization needs to protect its facility, equipment, and employees. Therefore, an organization needs to ensure that all areas are under surveillance so that security personnel notice improper actions and address them before damage occurs. Surveillance can happen through visual detection or through devices that use sophisticated means of detecting abnormal behavior or unwanted conditions. It is important that every organization have a proper mix of lighting, security personnel, IDSs, and surveillance technologies and techniques.

Visual Recording Devices

Because surveillance is based on sensory perception, surveillance devices usually work in conjunction with guards and other monitoring mechanisms to extend their capabilities and range of perception. A *closed-circuit TV (CCTV)* system is a commonly used monitoring device in most organizations, but before purchasing and implementing a CCTV system, you need to consider several items:

- **The purpose of CCTV** To detect, assess, and/or identify intruders
- **The type of environment the CCTV camera will work in** Internal or external areas
- **The field of view required** Large or small area to be monitored
- **Amount of illumination of the environment** Lit areas, unlit areas, areas affected by sunlight
- **Integration with other security controls** Guards, IDSs, alarm systems

The reason you need to consider these items before you purchase a CCTV product is that there are so many different types of cameras, lenses, and monitors that make up the different CCTV products. You must understand what is expected of this physical security control, so that you purchase and implement the right type.

CCTVs are made up of cameras, a controller and digital video recording (DVR) system, and a monitor. Remote storage and remote client access are usually added to prevent threat actors (criminals, fire) from destroying the recorded videos and to allow off-duty staff to report to alarms generated by the system without having to drive back to the office. The camera captures the data and transmits it to the controller, which allows the data to be displayed on a local monitor. The data is recorded so that it can be reviewed at a later time if needed. Figure 20-3 shows how multiple cameras can be connected to one controller, which allows several different areas to be monitored at one time. The controller accepts video feed from all the cameras and interleaves these transmissions over one line to the central monitor.

A CCTV sends the captured data from the cameras to the controller using a special network, which can be wired or wireless. The term "closed-circuit" comes from the fact that the very first systems used this special closed network instead of broadcasting the signals over a public network. This network should be encrypted so that an intruder

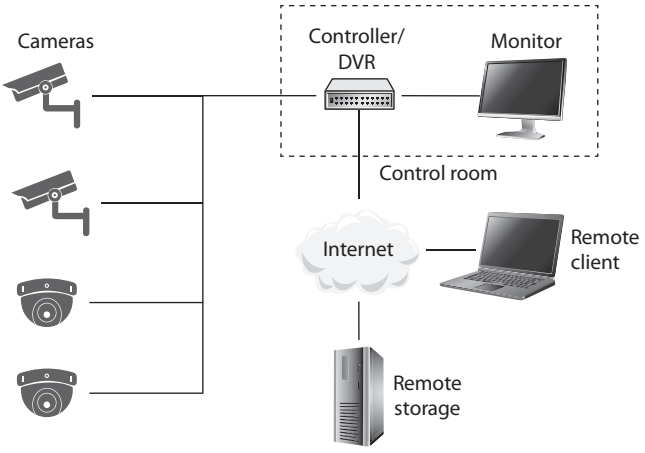


Figure 20-3 Several cameras can be connected to a DVR that can provide remote storage and access.

cannot manipulate the video feed that the security guard is monitoring. The most common type of attack is to replay previous recordings without the security personnel knowing it. For example, if an attacker is able to compromise a company's CCTV and play the recording from the day before, the security guard would not know an intruder is in the facility carrying out some type of crime. This is one reason why CCTVs should be used in conjunction with intruder detection controls, which we address in the next section.

Most of the CCTV cameras in use today employ light-sensitive chips called *charged-coupled devices (CCDs)*. The CCD is an electrical circuit that receives input light from the lens and converts it into an electronic signal, which is then displayed on the monitor. Images are focused through a lens onto the CCD chip surface, which forms the electrical representation of the optical image. It is this technology that allows for the capture of extraordinary detail of objects and precise representation, because it has sensors that work in the infrared range, which extends beyond human perception. The CCD sensor picks up this extra "data" and integrates it into the images shown on the monitor to allow for better granularity and quality in the video.

Two main types of lenses are used in CCTV: fixed focal length and zoom (varifocal). The *focal length* of a lens defines its effectiveness in viewing objects from a horizontal and vertical view. The focal length value relates to the angle of view that can be achieved. Short focal length lenses provide wider-angle views, while long focal length lenses provide a narrower view. The size of the images shown on a monitor, along with the area covered by one camera, is defined by the focal length. For example, if a company implements a CCTV camera in a warehouse, the focal length lens values should be between 2.8 and 4.3 millimeters (mm) so the whole area can be captured. If the company implements another CCTV camera that monitors an entrance, that lens value should be around 8 mm, which allows a smaller area to be monitored.

NOTE Fixed focal length lenses are available in various fields of views: wide, medium, and narrow. A lens that provides a "normal" focal length creates a picture that approximates the field of view of the human eye. A wide-angle lens has a short focal length, and a telephoto lens has a long focal length. When an organization selects a fixed focal length lens for a particular view of an environment, it should understand that if the field of view needs to be changed (wide to narrow), the lens must be changed.

So, if we need to monitor a large area, we use a lens with a smaller focal length value. Great, but what if a security guard hears a noise or thinks she sees something suspicious? A fixed focal length lens does not allow the user to optically change the area that fills the monitor. Though digital systems exist that allow this change to happen in logic, the resulting image quality is decreased as the area being studied becomes smaller. This is because the logic circuits are, in effect, cropping the broader image without increasing the number of pixels in it. This is called *digital zoom* (as opposed to optical zoom) and is a common feature in many cameras. The *optical zoom* lenses provide flexibility by allowing the viewer to change the field of view while maintaining the same number of pixels in the resulting image, which makes it much more detailed. The security personnel usually have a remote-control component integrated within the centralized CCTV monitoring area that allows them to move the cameras and zoom in and out on objects as needed. When both wide scenes and close-up captures are needed, an optical zoom lens is best.

To understand the next characteristic, depth of field, think about pictures you might take while on vacation with your family. For example, if you want to take a picture of your spouse with the Grand Canyon in the background, the main object of the picture is your spouse. Your camera is going to zoom in and use a *shallow depth of focus*. This provides a softer backdrop, which will lead the viewers of the photograph to the foreground, which is your spouse. Now, let's say you get tired of taking pictures of your spouse and want to get a scenic picture of just the Grand Canyon itself. The camera would use a *greater depth of focus*, so there is not such a distinction between objects in the foreground and background.

The depth of field is necessary to understand when choosing the correct lenses and configurations for your organization's CCTV. The *depth of field* refers to the portion of the environment that is in focus when shown on the monitor. The depth of field varies depending on the size of the lens opening, the distance of the object being focused on, and the focal length of the lens. The depth of field increases as the size of the lens opening decreases, the subject distance increases, or the focal length of the lens decreases. So, if you want to cover a large area and not focus on specific items, it is best to use a wide-angle lens and a small lens opening.

CCTV lenses have *irises*, which control the amount of light that enters the lens. *Manual iris lenses* have a ring around the CCTV lens that can be manually turned and controlled. A lens with a manual iris would be used in areas that have fixed lighting, since the iris cannot self-adjust to changes of light. An *auto iris lens* should be used in environments where the light changes, as in an outdoor setting. As the environment brightens, this is sensed by the iris, which automatically adjusts itself. Security personnel will configure

the CCTV to have a specific fixed exposure value, which the iris is responsible for maintaining. On a sunny day, the iris lens closes to reduce the amount of light entering the camera, while at night, the iris opens to capture more light—just like our eyes.

When choosing the right CCTV for the right environment, you must determine the amount of light present in the environment. Different CCTV camera and lens products have specific illumination requirements to ensure the best quality images possible. The illumination requirements are usually represented in the *lux* value, which is a metric used to represent illumination strengths. The illumination can be measured by using a light meter. The intensity of light (illumination) is measured and represented in measurement units of lux or foot-candles. (The conversion between the two is one foot-candle = 10.76 lux.) The illumination measurement is not something that can be accurately provided by the vendor of a light bulb, because the environment can directly affect the illumination. This is why illumination strengths are most effectively measured where the light source is implemented.

Next, you need to consider the mounting requirements of the CCTV cameras. The cameras can be implemented in a *fixed mounting* or in a mounting that allows the cameras to move when necessary. A fixed camera cannot move in response to security personnel commands, whereas cameras that provide *PTZ capabilities* can pan, tilt, or zoom (PTZ) as necessary. Either way, there is deterrence value in ensuring the cameras (or at least some of them) are visible. You should also place signs stating that everyone in the area is being monitored through CCTV. Threat actors may be less likely to engage in illicit behavior if they know they're being recorded on video doing so.

NOTE You should be mindful of the privacy implications of camera placement. Areas like restrooms, locker rooms, and medical exam rooms are examples of places where you should not install cameras unless you are certain you comply with all applicable laws, regulations, and ethical standards.

Now, it would be nice if someone actually watched the monitors for suspicious activities. Realizing that monitor watching is a mentally deadening activity may lead your team to implement a type of *annunciator system*. Different types of annunciator products are available that can either "listen" for noise and activate electrical devices, such as lights, sirens, or CCTV cameras, or detect movement. Instead of expecting a security guard to stare at a CCTV monitor for eight hours straight, the guard can carry out other activities and be alerted by an annunciator if movement is detected on a screen.

Facility Access Control

Access control needs to be enforced through physical and technical components when it comes to physical security. Physical access controls use mechanisms to identify individuals who are attempting to enter a facility or area. They make sure the right individuals get in and the wrong individuals stay out and provide an audit trail of these actions. Having personnel within sensitive areas is one of the best security controls because they can personally detect suspicious behavior. However, they need to be trained on what activity is considered suspicious and how to report such activity.

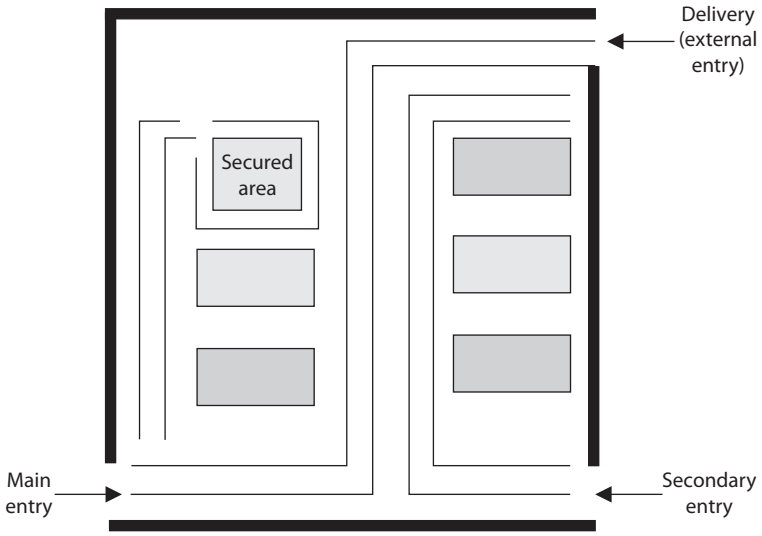


Figure 20-4 Access control points should be identified, marked, and monitored properly.

Before an organization can put into place the proper protection mechanisms, it needs to conduct a detailed review to identify which individuals should be allowed into what areas. Access control points can be identified and classified as external, main, and secondary entrances. Personnel should enter and exit through a specific entry, deliveries should be made to a different entry, and sensitive areas should be restricted. Figure 20-4 illustrates the different types of access control points into a facility. After an organization has identified and classified the access control points, the next step is to determine how to protect them.

Locks

Locks are inexpensive access control mechanisms that are widely accepted and used. They are considered *delaying* devices to intruders. The longer it takes to break or pick a lock, the longer a security guard or police officer has to arrive on the scene if the intruder has been detected. Almost any type of a door can be equipped with a lock, but keys can be easily lost and duplicated, and locks can be picked or broken. If an organization depends solely on a lock-and-key mechanism for protection, an individual who has the key can come and go as he likes without control and can remove items from the premises without detection. Locks should be used as part of the protection scheme, but should not be the sole protection scheme.

Locks vary in functionality. Padlocks can be used on chained fences, preset locks are usually used on doors, and programmable locks (requiring a combination to unlock) are used on doors or vaults. Locks come in all types and sizes. It is important to have the right type of lock so it provides the correct level of protection.

To the curious mind or a determined thief, a lock can be considered a little puzzle to solve, not a deterrent. In other words, locks may be merely a challenge, not necessarily something to stand in the way of malicious activities. Thus, you need to make the challenge difficult, through the complexity, strength, and quality of the locking mechanisms.

NOTE The delay time provided by the lock should match the penetration resistance of the surrounding components (door, door frame, hinges). A smart thief takes the path of least resistance, which may be to pick the lock, remove the pins from the hinges, or just kick down the door.

Mechanical Locks Two main types of mechanical locks are available: the warded lock and the tumbler lock. The warded lock is the basic padlock, as shown in Figure 20-5. It has a spring-loaded bolt with a notch cut in it. The key fits into this notch and slides the bolt from the locked to the unlocked position. The lock has wards in it, which are metal projections around the keyhole, as shown in Figure 20-6. The correct key for a specific warded lock has notches in it that fit in these projections and a notch to slide the bolt back and forth. These are the cheapest locks, because of their lack of any real sophistication, and are also the easiest to pick.

The *tumbler lock* has more pieces and parts than a ward lock. As shown in Figure 20-7, the key fits into a cylinder, which raises the lock metal pieces to the correct height so the bolt can slide to the locked or unlocked position. Once all of the metal pieces are at the correct level, the internal bolt can be turned. The proper key has the required size and sequences of notches to move these metal pieces into their correct position.

The three types of tumbler locks are the pin tumbler, wafer tumbler, and lever tumbler. The *pin tumbler lock*, shown in Figure 20-7, is the most commonly used tumbler lock. The key has to have just the right grooves to put all the spring-loaded pins in the right position so the lock can be locked or unlocked.

Figure 20-5
A warded lock

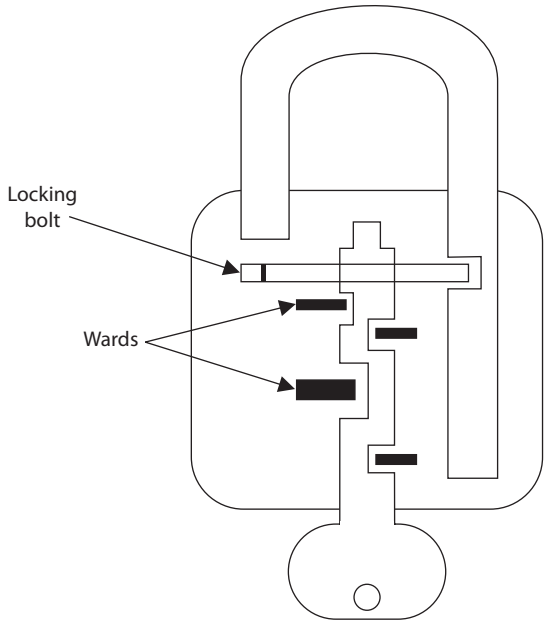


Figure 20-6
A key fits into a notch to turn the bolt to unlock the lock.

Wafer tumbler locks (also called *disc tumbler locks*) are the small, round locks you usually see on file cabinets. They use flat discs (wafers) instead of pins inside the locks. They often are used as car and desk locks. This type of lock does not provide much protection because it can be easily circumvented.

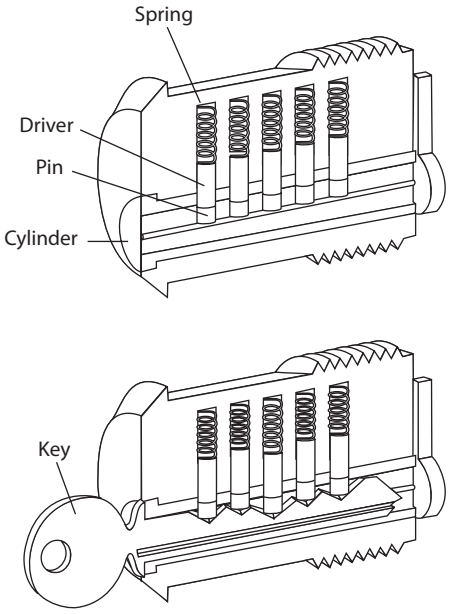


Figure 20-7
Tumbler lock

NOTE Some locks have interchangeable cores, which allow for the core of the lock to be taken out. You would use this type of lock if you wanted one key to open several locks. You would just replace all locks with the same core.

Combination locks, of course, require the correct combination of numbers to unlock them. These locks have internal wheels that have to line up properly before being unlocked. A user spins the lock interface left and right by so many clicks, which lines up the internal wheels. Once the correct turns have taken place, all the wheels are in the right position for the lock to release and open the door. The more wheels within the locks, the more protection provided. Electronic combination locks do not use internal wheels, but rather have a keypad that allows a person to type in the combination instead of turning a knob with a combination faceplate. An example of an electronic combination lock is shown in Figure 20-8.

Cipher locks, also known as *programmable locks*, are keyless and use keypads to control access into an area or facility. The lock requires a specific combination to be entered into the keypad and possibly a swipe card. Cipher locks cost more than traditional locks, but their combinations can be changed, specific combination sequence values can be locked out, and personnel who are in trouble or under duress can enter a specific code that will open the door and initiate a remote alarm at the same time. Thus, compared to traditional locks, cipher locks can provide a much higher level of security and control over who can access a facility.

The following are some functionalities commonly available on many cipher combination locks that improve the performance of access control and provide for increased security levels:

- **Door delay** If a door is held open for a given time, an alarm triggers to alert personnel of suspicious activity.
- **Key override** A specific combination can be programmed for use in emergency situations to override normal procedures or for supervisory overrides.
- **Master keying** Supervisory personnel can change access codes and other features of the cipher lock.
- **Hostage alarm** If an individual is under duress and/or held hostage, a combination he enters can communicate this situation to the guard station and/or police station.

Figure 20-8 An electronic combination lock

If a door is accompanied by a cipher lock, it should have a corresponding visibility shield so a bystander cannot see the combination as it is keyed in. Automated cipher locks must have a backup battery system and be set to unlock during a power failure so personnel are not trapped inside during an emergency. *Fail safe* systems are those that are designed and configured to ensure the safety of humans in the event of failure. Contrast this principle with *fail secure*, which we discussed in Chapter 9. These two imperatives (safety versus security) must be carefully balanced, while keeping in mind that human safety must always be the highest priority.

CAUTION It is important to change the combination of locks and to use random combination sequences. Often, people do not change their combinations or clean the keypads, which allows an intruder to know what key values are used in the combination, because they are the dirty and worn keys. The intruder then just needs to figure out the right combination of these values.

Some cipher locks require all users to know and use the same combination, which does not allow for any individual accountability. Some of the more sophisticated cipher locks permit specific codes to be assigned to unique individuals. This provides more accountability, because each individual is responsible for keeping his access code secret, and entry and exit activities can be logged and tracked. These are usually referred to as *smart locks*, because they are designed to allow only authorized individuals access at certain doors at certain times.

NOTE Hotel key cards are also known as smart cards. The access code on the card can allow access to a hotel room, workout area, business area, and better yet—the mini bar.

Device Locks Unfortunately, hardware has a tendency to "walk away" from facilities; thus, device locks are necessary to thwart these attempts. Cable locks consist of a vinyl-coated steel cable that can secure a computer or peripheral to a desk or other stationary components, as shown in Figure 20-9.

The following are some of the device locks available and their capabilities:

- **Switch controls** Cover on/off power switches
- **Slot locks** Secure the system to a stationary component by the use of steel cable that is connected to a bracket mounted in a spare expansion slot
- **Port controls** Block access to disk drives or unused serial or parallel ports
- **Peripheral switch controls** Secure a keyboard by inserting an on/off switch between the system unit and the keyboard input slot
- **Cable traps** Prevent the removal of input/output devices by passing their cables through a lockable unit

Figure 20-9 Laptop security cable kits secure a computer by enabling the user to attach the device to a stationary component within an area.

Administrative Responsibilities It is important for an organization not only to choose the right type of lock for the right purpose but also to follow proper maintenance and procedures. Keys should be assigned by facility management, and this assignment should be documented. Procedures should be written out detailing how keys are to be assigned, inventoried, and destroyed when necessary and what should happen if and when keys are lost. Someone on the organization's facility management team should be assigned the responsibility of overseeing key and combination maintenance.

Most organizations have master keys and submaster keys for the facility management staff. A master key opens all the locks within the facility, and the submaster keys open one or more locks. Each lock has its own individual unique keys as well. So if a facility has 100 offices, the occupant of each office can have his or her own key. A master key allows access to all offices for security personnel and for emergencies. If one security guard is responsible for monitoring half of the facility, the guard can be assigned one of the submaster keys for just those offices.

Since these master and submaster keys are powerful, they must be properly guarded and not widely shared. A security policy should outline what portions of the facility and which device types need to be locked. As a security professional, you should understand what type of lock is most appropriate for each situation, the level of protection provided by various types of locks, and how these locks can be circumvented.

Circumventing Locks Each lock type has corresponding tools that can be used to pick it (open it without the key). A tension wrench is a tool shaped like an L and is used to apply tension to the internal cylinder of a lock. The lock picker uses a lock pick to manipulate the individual pins to their proper placement. Once certain pins are "picked" (put in their correct place), the tension wrench holds these down while the lock picker figures out the correct settings for the other pins. After the intruder determines the proper pin placement, the wrench is used to then open the lock.

Intruders may carry out another technique, referred to as *raking*. To circumvent a pin tumbler lock, a lock pick is pushed to the back of the lock and quickly slid out while providing upward pressure. This movement makes many of the pins fall into place. A tension wrench is also put in to hold the pins that pop into the right place. If all the pins do not slide to the necessary height for the lock to open, the intruder holds the tension wrench and uses a thinner pick to move the rest of the pins into place.

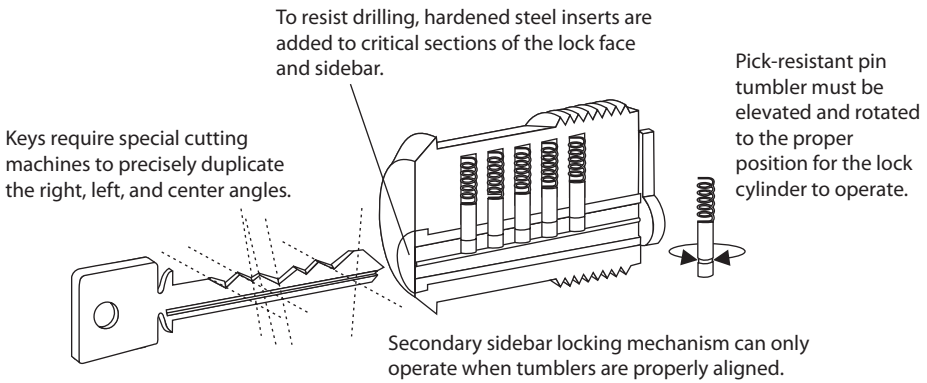
Lock Strengths

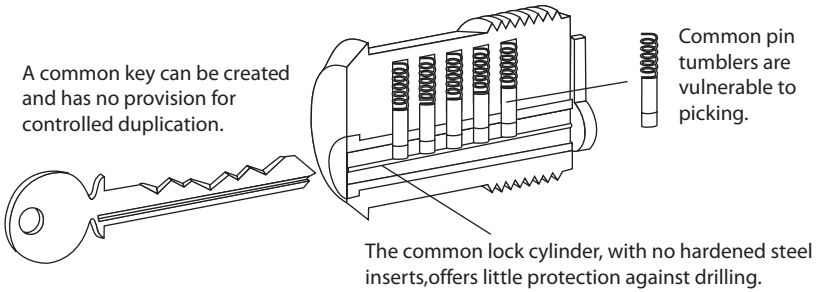
Basically, three grades of locks are available:

- **Grade 1** Commercial and industrial use
- **Grade 2** Heavy-duty residential/light-duty commercial
- **Grade 3** Residential/consumer

The cylinders within the locks fall into three main categories:

- **Low security** No pick or drill resistance provided (can fall within any of the three grades of locks)
- **Medium security** A degree of pick-resistance protection provided (uses tighter and more complex keyways [notch combination]; can fall within any of the three grades of locks)
- **High security** Pick-resistance protection through many different mechanisms (only used in grade 1 and 2 locks)





Lock bumping is a tactic that intruders can use to force the pins in a tumbler lock to their open position by using a special key called a *bump key*. The stronger the material that makes up the lock, the smaller the chance that this type of lock attack will be successful.

Now, if this is all too much trouble for the intruder, she can just drill the lock, use bolt cutters, attempt to break through the door or the doorframe, or remove the hinges. There are just so many choices for the bad guys.

Internal Security Controls

The physical security controls we've discussed so far have been focused on the perimeter. It is also important, however, to implement and manage internal security controls to mitigate risks when threat actors breach the perimeter or are insider threats. One type of control we already discussed in Chapter 10 is work area separation, in which we create internal perimeters around sensitive areas. For example, only designated IT and security personnel should be allowed in the server room. Access to these areas can then be restricted using locks and self-closing doors.

When implementing work area separation, we can start with a concentric zone model similar to the one we used for the external perimeter. Most staff will probably be able to move freely across the largest zone so that they can do their jobs. This general zone would have some controls, but not a bunch of them. Some staff members will also be allowed to go into more sensitive areas such as the operations center and the executive suite. These areas require some sort of access control like swiping a badge, but they're generally staffed so the people working there act as a sort of intrusion detection system when they see someone who doesn't belong. There can also be a highly sensitive zone that includes spaces where you really can't have any unauthorized persons, particularly if the spaces are not always staffed. Examples of these highly sensitive areas are server rooms, narcotic storage spaces (in healthcare facilities), and hazardous materials storerooms.

Physical security teams could include roving guards that move around the facility looking for potential security violations and unauthorized personnel. These teams could also monitor internal security cameras and be trained on how to respond to incidents such as medical emergencies and active shooters.

Personnel Access Controls

Proper identification verifies whether the person attempting to access a facility or area should actually be allowed in. Identification and authentication can be verified by matching an anatomical attribute (biometric system), using smart or memory cards (swipe cards), presenting a photo ID to a security guard, using a key, or providing a card and entering a password or PIN.

Personnel should be identified with badges that must be worn visibly while in the facility. The badges could include a photo of the individual and be color-coded to show clearance level, department, and whether or not that person is allowed to escort visitors. Visitors could be issued temporary badges that clearly identify them as such. All personnel would be trained to challenge anyone walking around without a badge or call security personnel to deal with them.

A common problem with controlling authorized access into a facility or area is called *piggybacking*. This occurs when an individual gains unauthorized access by using someone else's legitimate credentials or access rights. Usually, an individual just follows another person closely through a door without providing any credentials. The best preventive measures against piggybacking are to have security guards at access points and to educate employees about good security practices.

If an organization wants to use a card badge reader, it has several types of systems to choose from. Most systems are based on issuing to personnel cards that have embedded magnetic strips that contain access information. The reader can just look for simple access information within the magnetic strip, or it can be connected to a more sophisticated system that scans the information, makes more complex access decisions, and logs badge IDs and access times.

If the card is a memory card, then the reader just pulls information from it and makes an access decision. If the card is a smart card, the individual may be required to enter a PIN or password, which the reader compares against the information held within the card or in an authentication server.

These access cards can be used with *user-activated readers*, which just means the user actually has to do something—swipe the card or enter a PIN. *System sensing access control readers*, also called *transponders*, recognize the presence of an approaching object within a specific area. This type of system does not require the user to swipe the card through the reader. The reader sends out interrogating signals and obtains the access code from the card without the user having to do anything.

EXAM TIP *Electronic access control (EAC) tokens* is a generic term used to describe proximity authentication devices, such as proximity readers, programmable locks, or biometric systems, which identify and authenticate users before allowing them entrance into physically controlled areas.

Intrusion Detection Systems

Surveillance techniques are used to watch an area, whereas intrusion detection devices are used to sense changes that take place in an environment. Both are monitoring methods, but they use different devices and approaches. This section addresses the types of technologies that can be used to detect the presence of an intruder. One such technology, a perimeter scanning device, is shown in Figure 20-10.

IDSs are used to detect unauthorized entries and to alert a responsible entity to respond. These systems can monitor entries, doors, windows, devices, or removable coverings of equipment. Many work with magnetic contacts or vibration-detection devices that are sensitive to certain types of changes in the environment. When a change is detected, the IDS device sounds an alarm either in the local area or in both the local area and a remote police or guard station.

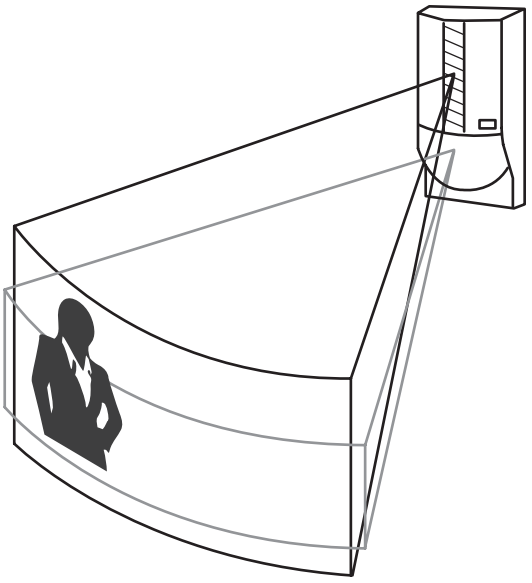


Figure 20-10 Different perimeter scanning devices work by covering a specific area.

IDSs can be used to detect changes in the following:

- Beams of light
- Sounds and vibrations
- Motion
- Different types of fields (microwave, ultrasonic, electrostatic)
- Electrical circuit

IDSs can be used to detect intruders by employing electromechanical systems (magnetic switches, metallic foil in windows, pressure mats) or volumetric systems. *Volumetric systems* are more sensitive because they detect changes in subtle environmental characteristics, such as vibration, microwaves, ultrasonic frequencies, infrared values, and photoelectric changes.

Electromechanical systems work by detecting a change or break in a circuit. The electrical circuits can be strips of foil embedded in or connected to windows. If the window breaks, the foil strip breaks, which sounds an alarm. Vibration detectors can detect movement on walls, screens, ceilings, and floors when the fine wires embedded within the structure are broken. Magnetic contact switches can be installed on windows and doors. If the contacts are separated because the window or door is opened, an alarm sounds. Another type of electromechanical detector is a pressure pad. This is placed underneath a rug or portion of the carpet and is activated after hours. If someone steps on the pad, an alarm is triggered.

A *photoelectric system*, or *photometric system*, detects the change in a light beam and thus can be used only in windowless rooms. These systems work like photoelectric smoke

detectors, which emit a beam that hits the receiver. If this beam of light is interrupted, an alarm sounds. The beams emitted by the photoelectric cell can be cross-sectional and can be invisible or visible beams. *Cross-sectional* means that one area can have several different light beams extending across it, which is usually carried out by using hidden mirrors to bounce the beam from one place to another until it hits the light receiver. These are the systems commonly depicted in movies. You have probably seen James Bond and other noteworthy movie spies or criminals use night-vision goggles to see the invisible beams and then step over them.

A *passive infrared (PIR) system* identifies the changes of heat waves in an area it is configured to monitor. If the particles' temperature within the air rises, it could be an indication of the presence of an intruder, so an alarm is sounded.

An *acoustical detection system* uses microphones installed on floors, walls, or ceilings. The goal is to detect any sound made during a forced entry. Although these systems are easily installed, they are very sensitive and cannot be used in areas open to sounds of storms or traffic. *Vibration sensors* are similar and are also implemented to detect forced entry. Financial institutions may choose to implement these types of sensors on exterior walls, where bank robbers may attempt to drive a vehicle through. They are also commonly used around the ceiling and flooring of vaults to detect someone trying to make an unauthorized bank withdrawal.

Wave-pattern motion detectors differ in the frequency of the waves they monitor. The different frequencies are microwave, ultrasonic, and low frequency. All of these devices generate a wave pattern that is sent over a sensitive area and reflected back to a receiver. If the pattern is returned undisturbed, the device does nothing. If the pattern returns altered because something in the room is moving, an alarm sounds.

A *proximity detector*, or *capacitance detector*, emits a measurable magnetic field. The detector monitors this magnetic field, and an alarm sounds if the field is disrupted. These devices are usually used to protect specific objects (e.g., artwork, cabinets, or a safe) versus protecting a whole room or area. Capacitance change in an electrostatic field can be used to catch a bad guy, but first you need to understand what capacitance change means. An electrostatic IDS creates an electrostatic magnetic field, which is just an electric field associated with static electric charges. Most objects have a measurable static electric charge. They are all made up of many subatomic particles, and when everything is stable and static, these particles constitute one holistic electric charge. This means there is a balance between the electric capacitance and inductance. Now, if an intruder enters the area, his subatomic particles will mess up this lovely balance in the electrostatic field, causing a capacitance change, and an alarm will sound. So if you want to rob a company that uses these types of detectors, leave the subatomic particles that make up your body at home.

The type of motion detector that an organization chooses to implement, its power capacity, and its configurations dictate the number of detectors needed to cover a sensitive area. Also, the size and shape of the room and the items within the room may cause barriers, in which case more detectors would be needed to provide the necessary level of coverage.

Intrusion Detection Systems Characteristics

IDSs are very valuable controls to use in every physical security program, but several issues need to be understood before implementing them:

- They are expensive and require human intervention to respond to the alarms.
- They require a redundant power supply and emergency backup power.
- They can be linked to a centralized security system.
- They should have a fail-safe configuration, which defaults to "activated."
- They should detect, and be resistant to, tampering.

IDSs are support mechanisms intended to detect and announce an attempted intrusion. They will not prevent or apprehend intruders, so they should be seen as an aid to the organization's security forces.

Patrol Force and Guards

One of the best intrusion detection mechanisms is a security guard and/or a patrol force to monitor a facility's grounds. This type of security control is more flexible than other security mechanisms, provides good response to suspicious activities, and works as a great deterrent. However, it can be a costly endeavor because it requires a salary, benefits, and time off. People sometimes are unreliable. Screening and bonding is an important part of selecting a security guard, but this only provides a certain level of assurance. One issue is if the security guard decides to make exceptions for people who do not follow the organization's approved policies. Because basic human nature is to trust and help people, a seemingly innocent favor can put an organization at risk.

IDSs and physical protection measures ultimately require human intervention. Security guards can be at a fixed post or can patrol specific areas. Different organizations will have different needs from security guards. They may be required to check individual credentials and enforce filling out a sign-in log. They may be responsible for monitoring IDSs and expected to respond to alarms. They may need to issue and recover visitor badges, respond to fire alarms, enforce rules established by the company within the building, and control what materials can come into or go out of the environment. The guard may need to verify that doors, windows, safes, and vaults are secured; report identified safety hazards; enforce restrictions of sensitive areas; and escort individuals throughout facilities.

The security guard should have clear and decisive tasks that she is expected to fulfill. The guard should be fully trained on the activities she is expected to perform and on the responses expected from her in different situations. She should also have a central control point to check in to, two-way radios to ensure proper communication, and the necessary access into areas she is responsible for protecting.

The best security has a combination of security mechanisms and does not depend on just one component of security. Thus, a security guard should be accompanied by other surveillance and detection mechanisms.

Dogs

Dogs have proven to be highly useful in detecting intruders and other unwanted conditions. Their senses of smell and hearing outperform those of humans, and their intelligence and loyalty can be used for protection. The best security dogs go through intensive training to respond to a wide range of commands and to perform many tasks. Dogs can be trained to hold an intruder at bay until security personnel arrive or to chase an intruder and attack. Some dogs are trained to smell smoke so they can alert personnel to a fire.

Of course, dogs cannot always know the difference between an authorized person and an unauthorized person, so if an employee goes into work after hours, he can have more on his hands than expected. Dogs can provide a good supplementary security mechanism.

EXAM TIP Because the use of guard dogs introduces significant risks to personal safety, which is paramount for CISSPs, exam answers that include dogs are likelier to be incorrect. Be on the lookout for these.

Auditing Physical Access

Physical access control systems can use software and auditing features to produce audit trails or access logs pertaining to access attempts. The following information should be logged and reviewed:

- The date and time of the access attempt
- The entry point at which access was attempted
- The user ID employed when access was attempted
- Any unsuccessful access attempts, especially if during unauthorized hours

As with audit logs produced by computers, access logs are useless unless someone actually reviews them. A security guard may be required to review these logs, but a security professional or a facility manager should also review these logs periodically. Management needs to know where entry points into the facility exist and who attempts to use them.

Audit and access logs are detective controls, not preventive controls. They are used to piece together a situation after the fact instead of attempting to prevent an access attempt in the first place.

Personnel Safety and Security

The single most valuable asset for an organization, and the one that involves the highest moral and ethical standards, is its people. Our safety focus in security operations will be on our own employees, but we also need to take proper steps to ensure the safety

of visitors, clients, and anyone who enters into our physical or virtual spaces. While the scope of safety is broader than information systems security, information security professionals make important contributions to this effort.

EXAM TIP Human safety almost always trumps all other concerns. If an exam question has a possible answer that focuses on safety, it is likelier to be the right one.

Travel

Personnel safety in the workplace is one thing, but how do we protect our staff while they are traveling? There are a host of considerations we should take. The most basic one is to determine the threat landscape at the destination. Some organizations go as far as having country-specific briefings that are regularly updated and required for all staff traveling overseas. This is obviously a resource-intensive proposition, but there are free alternatives you can leverage. Many governments have departments or ministries that publish this information for their citizens traveling abroad. For example, the U.S. Department of State publishes travel advisories on its website for virtually any destination.

Speaking of these government entities, it is also important for traveling staff to know the location and contact information for the nearest embassy or consulate. In case of emergency, these offices provide a variety of important services. Depending on the threat condition at the destination, it may be a good idea to notify these offices of staff members' contact information, dates of travel, and places of lodging.

Hotel security starts by doing a bit of research ahead of the trip. If you've never stayed in a specific hotel, a few minutes of web searching will give you a good indication of whether or not it's safe. Here are some other best practices that your organization's staff should consider when traveling:

- Ask for a room on the second floor. It reduces the risk of random criminal activity and is still close enough to the ground to escape in case of an emergency even if you can't use the front door.
- Ask for and keep a hotel business card on your person at all times in case you have to call the local police or embassy and provide your location in an emergency.
- Secure valuables in the in-room safe. It may not really be totally secure, but it raises the bar on would-be thieves.
- Always use the security latch on the door when in the room.
- Keep your passport with you at all times when in a foreign country. Before the trip leave a photocopy of the passport with a trusted individual at home.

Security Training and Awareness

All these personal safety measures are good only if your organization's staff actually knows what they are and how and when to use them. Many organizations have mandatory training events for all staff, and personal security should be part of it. Keep in mind that

emergency procedures, panic codes/passwords, and travel security measures are quickly forgotten if they are not periodically reinforced.

Emergency Management

A common tool for ensuring the safety of personnel during emergencies is the occupant emergency plan (OEP). The OEP describes the actions that facility occupants should take to ensure their safety during an emergency situation. This plan should address the range of emergencies from individual to facility-wide, and it should be integrated into the security operations of the organization.

Perhaps the best example of the intersection of safety and security occurs in the area of physical access control. A well-designed system of physical access controls constrains the movement of specific individuals in and out of certain spaces. For instance, we only want authorized persons to enter the server room. But what if the server room offers the best escape route for people who would normally not be allowed in it? While we would not design a facility in which this would be the case, we sometimes end up occupying less-than-ideal facilities. If this were the case, what process would we implement to ensure we can get people out of the building quickly and not force them to take a circuitous route that could put them in danger, but keeps them out of the sensitive area?

Another example involves access for emergency responders. If a fire alarm is triggered in the building, how do we ensure we can evacuate all personnel while giving fire fighters access to all spaces (without requiring them to break down doors)? In this context, how do we simultaneously ensure the safety of our personnel while maintaining security of our information systems?

Lastly, many modern physical access controls require electricity. If an electronic lock does not have a battery backup, will it automatically unlock in the absence of power or will it remain in the locked state? A *fail-safe device* is one that automatically moves to the state that ensures safety in the event of a failure such as loss of power. Fail-safe controls, while critical to human safety, must be carefully considered because they introduce risks to the security of our information systems.

Duress

Duress is the use of threats or violence against someone in order to force them to do something they don't want to do or otherwise wouldn't do. Like any other threat, we need to factor in duress in our risk assessment and figure out what (if anything) to do about it. A popular example of a countermeasure for duress is the use of panic buttons by bank tellers. The button is hidden where an assailant can't see it but where the teller can easily and discretely activate it to warn the police. A twist on this is the use of duress codes in some alarm systems. The alarm has a keypad where an authorized person can enter a secret code to deactivate it. The system can have two different codes: a regular one that disarms the alarm, and a second one that also disarms the alarm but also alerts authorities to an emergency. If someone was forcing you to disarm an alarm, you'd enter the second code and they wouldn't be able to know that you just summoned the police.

Duress codes can also be verbal. For example, some alarm systems have an attendant call the facility to ensure everything is fine. If someone is under duress (and perhaps on speakerphone next to the assailant) you would want a discrete way for that person to convey that they are in danger. You could set up two possible responses, like "apple pie," which would mean you are in danger, and "sunshine," which would mean everything is truly fine. The key is to make the duress response sound completely benign.

Another situation to consider is when an assailant forces an employee to log into their account. You could set up a duress account with a username that is very similar to the real one. Upon login, the duress account looks just like the real one, except that it doesn't include sensitive content. The twist is that the duress password could do a range of things from activating full monitoring (like camera, keyboard, and packet logging) to quietly wiping the device in the background (useful for laptops being used away from the office). Obviously, it would also generate an alert to security personnel that the user is in danger.

Chapter Review

This chapter was a bit of a whirlwind tour of many of the issues we need to manage as part of security operations. We covered a lot of ground, but keep in mind that these are all important topics you need to address in your organization if you want to operationalize security. Collectively, this chapter lays the foundation for the tasks many of us prefer to be doing: blocking bad actors from gaining access, finding the ones that sneak in, and frustrating their efforts to cause us harm. We dive into those in the next three chapters as we delve into day-to-day security operations, incident response, and dealing with disasters.

Quick Review

- SecOps (Security + Operations) is the integration of security and IT operations people, technology, and processes to reduce risks while improving business agility.
- Access to resources should be limited to authorized personnel, applications, and services and should be audited for compliance to stated policies.
- Least privilege means an individual should have just enough permissions and rights to fulfill his role in the company and no more.
- Need to know means we must first establish that an individual has a legitimate, job role–related need for a given resource before granting access to it.
- Separation of duties and responsibilities should be in place so that fraud cannot take place without collusion of two or more people.
- Privileged account management formally enforces the principle of least privilege on accounts with elevated rights.
- Job rotation means that, over time, more than one person fulfills the tasks of one position within the organization, which provides backup and redundancy but also helps identify fraudulent activities.

- A service level agreement (SLA) is a contract that states that a service provider guarantees a certain level of service to a customer.
- Change management is the practice of minimizing the risks associated with the addition, modification, or removal of anything that could have an effect on IT services.
- Activities that involve change management include requesting, evaluating, planning, implementing, reviewing, and closing or sustaining a change.
- Configuration management is the process of establishing and maintaining consistent configurations on all our systems to meet organizational requirements.
- A baseline is the configuration of a system at a point in time as agreed upon by the appropriate decision makers.
- Vulnerability management is the cyclical process of identifying vulnerabilities, determining the risks they pose to the organization, and applying security controls that bring those risks to acceptable levels.
- Patch management is the process for identifying, acquiring, installing, and verifying patches for products and systems.
- Facilities that house systems that process sensitive information should have physical access controls to limit access to authorized personnel only.
- Exterior fencing can be costly and unsightly, but can provide crowd control and help control access to the facility, particularly if the fencing is eight feet or higher.
- Closed-circuit TV (CCTV) systems are made up of cameras, a controller and digital video recording (DVR) system, and a monitor, but frequently also include remote storage and remote client access.
- Locks are considered delaying devices to intruders.
- Some physical security controls may conflict with the safety of people. These issues need to be addressed; human life is always more important than protecting a facility or the assets it contains.
- Piggybacking occurs when an individual gains unauthorized access by using someone else's legitimate credentials or access rights, usually when the intruder closely follows an authorized person through a door or gate.
- Proximity identification devices can be user activated (action needs to be taken by a user) or system sensing (no action needs to be taken by the user).
- A transponder is a proximity-based access control reader that does not require action by the user. The reader transmits signals to the device, and the device responds with an access code.
- Intrusion detection devices include motion detectors, CCTVs, vibration sensors, and electromechanical devices.
- Intrusion detection devices can be penetrated, are expensive to install and monitor, require human response, and are subject to false alarms.

- Security guards are expensive but provide flexibility in response to security breaches and can deter intruders from attempting an attack.
- Dogs are very effective at detecting and deterring intruders, but introduce significant risks to personal safety.
- Duress is the use of threats or violence against someone in order to force them to do something they don't want to do or otherwise wouldn't do.

Questions

Please remember that these questions are formatted and asked in a certain way for a reason. Keep in mind that the CISSP exam is asking questions at a conceptual level. Questions may not always have the perfect answer, and the candidate is advised against always looking for the perfect answer. Instead, the candidate should look for the best answer in the list.

1. Why should employers make sure employees take their vacations?

A. They have a legal obligation.

B. It is part of due diligence.

C. It is a way for fraud to be uncovered.

D. To ensure employees do not get burned out.

2. Which of the following best describes separation of duties and job rotation?

A. Separation of duties ensures that more than one employee knows how to perform the tasks of a position, and job rotation ensures that one person cannot perform a high-risk task alone.

B. Separation of duties ensures that one person cannot perform a high-risk task alone, and job rotation can uncover fraud and ensure that more than one person knows the tasks of a position.

C. They are the same thing, but with different titles.

D. They are administrative controls that enforce access control and protect the organization's resources.

3. If a programmer is restricted from updating and modifying production code, what is this an example of?

A. Rotation of duties

B. Due diligence

C. Separation of duties

D. Controlling input values

4. What is the difference between least privilege and need to know?

A. A user should have least privilege that restricts her need to know.

B. A user should have a security clearance to access resources, a need to know about those resources, and least privilege to give her full control of all resources.

C. A user should have a need to know to access particular resources, and least privilege should be implemented to ensure she only accesses the resources she has a need to know.

D. They are two different terms for the same issue.

5. Which of the following would not require updated documentation?

A. An antivirus signature update

B. Reconfiguration of a server

C. A change in security policy

D. The installation of a patch to a production server

6. A company needs to implement a CCTV system that will monitor a large area outside the facility. Which of the following is the correct lens combination for this?

A. A wide-angle lens and a small lens opening

B. A wide-angle lens and a large lens opening

C. A wide-angle lens and a large lens opening with a small focal length

D. A wide-angle lens and a large lens opening with a large focal length

7. Which of the following is not a true statement about CCTV lenses?

A. Lenses that have a manual iris should be used in outside monitoring.

B. Zoom lenses carry out focus functionality automatically.

C. Depth of field increases as the size of the lens opening decreases.

D. Depth of field increases as the focal length of the lens decreases.

8. What is true about a transponder?

A. It is a card that can be read without sliding it through a card reader.

B. It is a biometric proximity device.

C. It is a card that a user swipes through a card reader to gain access to a facility.

D. It exchanges tokens with an authentication server.

9. When is a security guard the best choice for a physical access control mechanism?

A. When discriminating judgment is required

B. When intrusion detection is required

C. When the security budget is low

D. When access controls are in place

10. Which of the following is not a characteristic of an electrostatic intrusion detection system?

- **A.** It creates an electrostatic field and monitors for a capacitance change.
- **B.** It can be used as an intrusion detection system for large areas.
- **C.** It produces a balance between the electric capacitance and inductance of an object.
- **D.** It can detect if an intruder comes within a certain range of an object.

11. What is a common problem with vibration-detection devices used for perimeter security?

- **A.** They can be defeated by emitting the right electrical signals in the protected area.
- **B.** The power source is easily disabled.
- **C.** They cause false alarms.
- **D.** They interfere with computing devices.

12. Which of the following is not considered a delaying mechanism?

- **A.** Locks
- **B.** Defense-in-depth measures
- **C.** Warning signs
- **D.** Access controls

13. What are the two general types of proximity identification devices?

- **A.** Biometric devices and access control devices
- **B.** Swipe card devices and passive devices
- **C.** Preset code devices and wireless devices
- **D.** User-activated devices and system sensing devices

14. Which is not a drawback of an intrusion detection system?

- **A.** It's expensive to install.
- **B.** It cannot be penetrated.
- **C.** It requires human response.
- **D.** It's subject to false alarms.

15. What is a cipher lock?

- **A.** A lock that uses cryptographic keys
- **B.** A lock that uses a type of key that cannot be reproduced
- **C.** A lock that uses a token and perimeter reader
- **D.** A lock that uses a keypad

16. If a cipher lock has a door delay option, what does that mean?
    A. After a door is open for a specific period, the alarm goes off.
    B. It can only be opened during emergency situations.
    C. It has a hostage alarm capability.
    D. It has supervisory override capability.

Answers

1. **C.** Many times, employees who are carrying out fraudulent activities do not take the vacation they have earned because they do not want anyone to find out what they have been doing. Forcing an employee to take a vacation means that someone else has to do that person's job and can possibly uncover any misdeeds.
2. **B.** Rotation of duties enables an organization to have more than one person trained in a position and can uncover fraudulent activities. Separation of duties is put into place to ensure that one entity cannot carry out a critical task alone.
3. **C.** This is just one of several examples of separation of duties. A system must be set up for proper code maintenance to take place when necessary, instead of allowing a programmer to make changes arbitrarily. These types of changes should go through a change control process and should have more entities involved than just one programmer.
4. **C.** Users should be able to access only the resources they need to fulfill the duties of their positions. They also should only have the level of permissions and rights for those resources that are required to carry out the exact operations they need for their jobs, and no more. This second concept is more granular than the first, but they have a symbiotic relationship.
5. **A.** Documentation is a very important part of the change control process. If things are not properly documented, employees will forget what actually took place with each device. If the environment needs to be rebuilt, for example, it may be done incorrectly if the procedure was poorly or improperly documented. When new changes need to be implemented, the current infrastructure may not be totally understood. Continually documenting when virus signatures are updated would be overkill. The other answers contain events that certainly require documentation.
6. **A.** The depth of field refers to the portion of the environment that is in focus when shown on the monitor. The depth of field varies depending upon the size of the lens opening, the distance of the object being focused on, and the focal length of the lens. The depth of field increases as the size of the lens opening decreases, the subject distance increases, or the focal length of the lens decreases. So if you want to cover a large area and not focus on specific items, it is best to use a wide-angle lens and a small lens opening.
7. **A.** Manual iris lenses have a ring around the CCTV lens that can be manually turned and controlled. A lens that has a manual iris would be used in an area that has fixed lighting, since the iris cannot self-adjust to changes of light. An auto iris

lens should be used in environments where the light changes, such as an outdoor setting. As the environment brightens, this is sensed by the iris, which automatically adjusts itself. Security personnel will configure the CCTV to have a specific fixed exposure value, which the iris is responsible for maintaining. The other answers are true statements about CCTV lenses.

8. **A.** A transponder is a type of proximity-based access control device that does not require the user to slide a card through a reader. The reader and card communicate directly. The card and reader have a receiver, transmitter, and battery. The reader sends signals to the card to request information. The card sends the reader an access code.
9. **A.** Although many effective physical security mechanisms are on the market today, none can look at a situation, make a judgment about it, and decide what the next step should be. A security guard is employed when an organization needs to have a countermeasure that can think and make decisions in different scenarios.
10. **B.** An electrostatic IDS creates an electrostatic field, which is just an electric field associated with static electric charges. The IDS creates a balanced electrostatic field between itself and the object being monitored. If an intruder comes within a certain range of the monitored object, there is capacitance change. The IDS can detect this change and sound an alarm.
11. **C.** This type of system is sensitive to sounds and vibrations and detects the changes in the noise level of an area it is placed within. This level of sensitivity can cause many false alarms. These devices do not emit any waves; they only listen for sounds within an area and are considered passive devices.
12. **C.** Every physical security program should have delaying mechanisms, which have the purpose of slowing down an intruder so security personnel can be alerted and arrive at the scene. A warning sign is a deterrence control, not a delaying control.
13. **D.** A user-activated device requires the user to do something: swipe the card through the reader and/or enter a code. A system sensing device recognizes the presence of the card and communicates with it without the user needing to carry out any activity.
14. **B.** Intrusion detection systems are expensive, require someone to respond when they set off an alarm, and, because of their level of sensitivity, can cause several false alarms. Like any other type of technology or device, they have their own vulnerabilities that can be exploited and penetrated.
15. **D.** Cipher locks, also known as programmable locks, use keypads to control access into an area or facility. The lock can require a swipe card and a specific combination that's entered into the keypad.
16. **A.** A security guard would want to be alerted when a door has been open for an extended period. It may be an indication that something is taking place other than a person entering or exiting the door. A security system can have a threshold set so that if the door is open past the defined time period, an alarm sounds.

CHAPTER 21

Security Operations

This chapter presents the following:

- The security operations center (SOC)
- Preventive and detective measures
- Logging and monitoring

There are two types of companies in the world: those that know they've been hacked, and those that don't.

—Misha Glenny

Security operations pertains to everything that takes place to keep networks, computer systems, applications, and environments up and running in a secure and protected manner. But even if you take great care to ensure you are watching your perimeters (both virtual and physical) and ensuring that you provision new services and retire unneeded ones in a secure manner, odds are that some threat source will be able to compromise your information systems. What then? Security operations also involves the detection, containment, eradication, and recovery that is required to ensure the continuity of business operations.

Most of the necessary operational security issues have been addressed in earlier chapters. They were integrated with related topics and not necessarily pointed out as actual operational security issues. So instead of repeating what has already been stated, this chapter reviews and points out the operational security topics that are important for organizations and CISSP candidates.

The Security Operations Center

The security operations center (SOC) is the nerve center of security operations in organizations with a mature information security management system (ISMS). The SOC encompasses the people, processes, and technology that support logging and monitoring of preventive controls, detection of security events, and incident response. By integrating them together in the SOC, an organization streamlines the process of detecting and responding to threats, thereby minimizing organizational losses. In the aftermath of a security incident, lessons learned can be uniformly applied to better mitigate future threats. As defensive processes evolve, they can be rehearsed easily because everyone is on the same team.

Elements of a Mature SOC

Figure 21-1 shows a high-level view of the core elements of a typical mature SOC. More important than the specific components is the fact that they are integrated so that security tasks are performed in a coordinated manner. Still, it's hard to have a SOC that doesn't have at least the three platforms shown in the figure. The *endpoint detection and response (EDR)* tool is deployed on all endpoints and monitors user and process behaviors. Anything like suspicious activities or suspected malware is reported to a central management system, which is typically the *security information and event management (SIEM)* platform. Of course, the EDR can't tell what is going on across the networks, so we need a tool to monitor those for suspicious activity. This is the role of the *network detection and response (NDR)* system, which similarly reports its findings to the SIEM solution. The SIEM solution aggregates these (and many other) data feeds and provides a holistic view into all the security-related information in the organizational environment.

Tier 1 security analysts spend most of their time monitoring security tools and other technology platforms for suspicious activity. For all their sophistication, these tools tend to generate a lot of false positives (that is, false alarms), so we need people to go through and verify the alerts generated by these tools. These analysts are typically the least experienced, so their job is to triage alerts, handling the more mundane and passing on the more complex and dangerous ones to the more experienced staff in the SOC. Tier 2 analysts can dig deeper into the alerts to determine if they constitute security incidents. If they do, these analysts can then coordinate with incident responders and intelligence analysts to further investigate, contain, and eradicate the threats.

The key to a good SOC is to have the policies and procedures in place to ensure the platforms are well tuned, the team is trained and working together, and the context of the organization's business is considered in every action taken. This business context

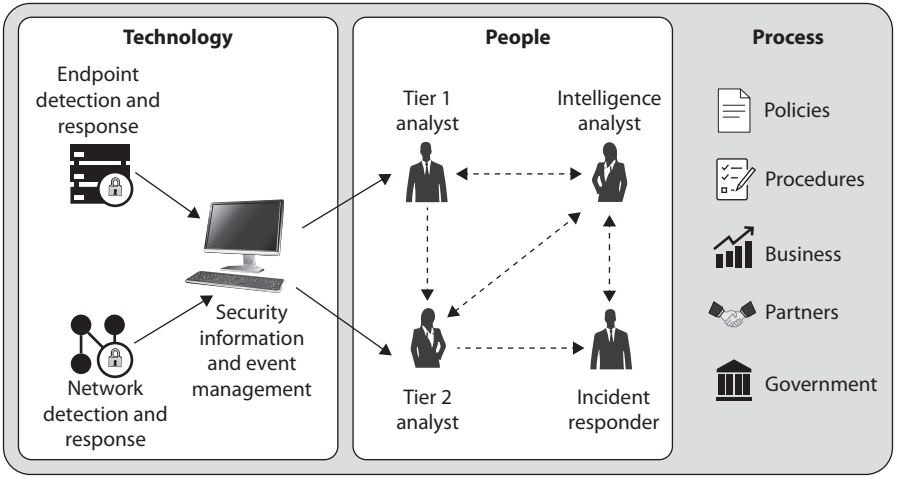


Figure 21-1 Core elements of a mature SOC

includes partners and customers, because the SOC needs to understand the entire ecosystem within which the organization operates. Occasionally, liaising with appropriate government organizations will also be needed, and the SOC must be prepared to do so. Examples of this are scenarios that require reporting cybercrimes and exchanging threat intelligence with the appropriate agencies.

Threat Intelligence

One of the key capabilities of a SOC is to consume (and, ideally, develop) threat intelligence. Gartner defines *threat intelligence* as "evidence-based knowledge…about an existing or emerging menace or hazard to assets. This intelligence can be used to inform decisions regarding the subject's response to that menace or hazard." In other words, threat intelligence is information about our adversaries' past, present, and future actions that allows us to respond or prevent them from being successful. From this definition flow four essential characteristics of good intelligence, known by the acronym CART:

- **Complete** Sufficient to detect or prevent the threat from being realized
- **Accurate** Factual and free from errors
- **Relevant** Useful to detect and prevent the threat from being realized
- **Timely** Received and operationalized fast enough to make an impact

It is important to keep in mind that threat intelligence is meant to help decision-makers choose what to do about a threat. It answers a question that these leaders may have. For example, a C-suite executive may ask a strategic question like, "What cyberthreats will be targeting our industry in the next year?" That person probably doesn't care about (or understand) the technical details of the tools the SOC is using. The SOC director, on the other hand, is interested in tactical issues and may need to know the technical details in order to respond to ongoing threats. The SOC director may ask what command and control infrastructure a particular threat actor is using. So, all good intelligence is, essentially, an answer to a question asked by a decision-maker in the organization. These questions are the requirements that drive the intelligence cycle shown in Figure 21-2.

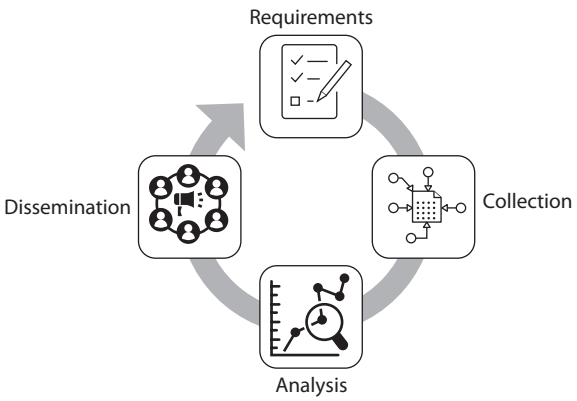


Figure 21-2 The intelligence cycle

Once the requirements are known and prioritized, the intelligence analyst can get to work collecting data that can help answer those questions. The next section discusses the different data sources that analysts can use, but for now, the important point to consider is that intelligence analysts shouldn't have to start from scratch when it comes to identifying the data sources. A good collection management framework (CMF) allows an organization to determine where data lives that can answer the questions that are being asked by its leaders and identify informational "blind spots" that need to be addressed by developing new data sources.

The data that is collected still needs to be analyzed before it yields intelligence products. The analysis step involves integrating the data and evaluating it. Intelligence analysts may reach out to subject matter experts to ensure specific data items are reliable, valid, and relevant, and to help put them into a broader context. Sometimes the data items will contradict each other, so these conflicts need to be resolved before drawing final conclusions.

The final step in the intelligence cycle is to share the finished intelligence with the appropriate decision-makers. Because the intelligence requirement was meant to answer a question from a given individual (or class of individuals), the analyst already knows how to phrase the report. If the report is going to an executive, it should be written in a nontechnical manner (but, ideally, with a more technical appendix that explains where the conclusions come from). If the report is going to cybersecurity professionals, it requires a lot more technical data.

Typically, one full iteration of the intelligence cycle leads to further questions that must be answered. These questions feed the next cycle by becoming (or contributing to) new intelligence requirements.

Threat Data Sources

Let's get back to the threat data sources that are needed to address intelligence requirements. Numerous third parties offer free or paid threat data feeds. These are subscription services that constantly (or periodically) feed information such as indicators of compromise (IOCs); an IOC is technical data that is characteristic of malicious activity. For example, we may know that a particular domain name is being used to deliver ransomware to compromised targets, so that domain name is an IOC for that particular threat. Unless the question that drove an intelligence requirement was "What is one domain used in ransomware attacks?" this IOC, by itself, would not be an intelligence product. Rather, it is an example of the first of three types of data sources commonly used in cyberthreat intelligence: third-party data feeds.

Another important type of data source is called *open-source intelligence (OSINT)*, which is the name collectively given to any source that is freely available on the Internet. Often, we can get the information we need simply by doing a web search for it. Of course, there are also tools that make this process much easier by integrating queries against multiple open sources. Over time, intelligence analysts assemble lists of URLs that prove useful to their specific intelligence needs.

The third type of commonly used data source, and in many ways the most important, is internal sources. These are sources under the direct control of the organization and that

can be tasked to collect data. For example, you may task your DNS server to provide all the domain names for which clients in your organization are requesting resolution. This would likely be a very large list full of repeated entries, particularly for popular domains. From it, however, you could gather data such as newly observed domains (NODs) or domains with a small community of interest (COI) in your organization. Either could be an early indicator of an attack, though it would be fraught with false positives.

Cyberthreat Hunting

If you have a threat intelligence program in your organization, you can use it to stay one step ahead of the adversaries (or at least just one step behind). *Cyberthreat hunting* is the practice of proactively looking for threat actors in your networks. In other words, instead of waiting for an alert from your SIEM system to start investigating an incident, you develop a hypothesis of what an adversary may be up to (informed by threat intelligence, of course) and then set about proving or negating that hypothesis.

For example, suppose that threat intelligence reveals that other organizations in your sector are being targeted by attackers who are enabling the Remote Desktop Protocol (RDP) to move laterally across the environment. RDP is normally disabled in your organization except for on a handful of jump boxes (hardened hosts that act as a secure entry point or gateway into a sensitive part of a network). From these two facts, you develop the hypothesis that an adversary is enabling RDP on regular workstations to move laterally over your organization's networks. Your hunt operation will be centered on proving your hypothesis (by finding evidence that this is going on) or negating it (by finding no workstations with RDP inappropriately enabled). Your hunt would involve checking the registry of every Windows endpoint in your environment, examining the Windows Registry keys that enable Remote Desktop Services (RDS). Hopefully, you would write a script that does this for you automatedly, so you don't have to manually check every endpoint. Suppose you find several endpoints with RDS enabled. You now narrow your hunt to those systems and determine whether they are a) legitimately authorized to use RDS, b) authorized for RDS but didn't follow the configuration management process, or c) evidence of adversarial activities.

This is the crux of threat hunting: you develop a hypothesis of adversarial action based on threat intelligence, and then you prove or negate your hypothesis. Threat hunting is inherently proactive and based on intelligence, whereas incident response is reactive and based on alerts. Because threat hunting requires the skills of intelligence analysts, cybersecurity analysts (typically tier 2), and incident responders, many organizations stand up hunt teams with one or more members from each of these three roles. The team may run a hunt campaign consisting of multiple related hunt operations, and then return to their daily jobs until they're needed for the next campaign.

EXAM TIP Threat hunting involves *proactively* searching for malicious activities that were not detected by other means. If you already know there's been an incident, then you are *reactively* responding to it. This key difference between threat hunting and incident response is important to remember.

Preventive and Detective Measures

As exciting and effective as cyberthreat hunting can be, relatively few organizations have the resources to engage in this effort consistently. Even in organizations that do have the resources, most of the efforts of security operations are focused on preventing and detecting security incidents. A good way to reduce the likelihood of contingencies and disasters is to ensure that your organization's defensive architectures include the right set of tools. These technical controls need to be carefully considered in the context of your organization's own conditions to determine which are useful and which aren't. Regardless of the tools you employ, there is an underlying process that drives their operation in a live environment. The steps of this generalized process are described here:

1. *Understand the risk.* Chapter 2 presented the risk management process that organizations should use. The premise of this process is that you can't ever eliminate all risks and should therefore devote your scarce resources to mitigating the most dangerous risks to a point where their likelihood is acceptable to the senior leaders. If you don't focus on that set of risks, you will likely squander your resources countering threats that are not the ones your CEO is really concerned about.
2. *Use the right controls.* Once you are focused on the right set of risks, you can more easily identify the controls that will appropriately mitigate them. The relationship between risks and controls is many to many, since a given risk can have multiple controls assigned to it and a given control can be used to mitigate multiple risks. In fact, the number of risks mitigated by one control should give you an indicator of the value of that control to the organization. On the other hand, having multiple controls mitigating a risk may be less efficient, but may provide resiliency.
3. *Use the controls correctly.* Selecting the right tools is only part of the battle. You also need to ensure they are emplaced and configured correctly. The network architectures covered in Chapter 7 place some very significant limitations on the effectiveness of tools based on where they are plugged in. If an IDS is deployed on the wrong subnet, it may not be able to monitor all the traffic from the threat sources against which it is supposed to defend. Similarly, that same IDS with the wrong configuration or rule set could well become an expensive ornament on the network.
4. *Manage your configuration.* One of the certainties in life is that, left alone, every configuration is guaranteed to become obsolete at some point in the future. Even if it is not left alone, making unauthorized or undocumented changes will introduce risk at best and at worst quietly render your network vulnerable to an immediate threat. Properly done, configuration management will ensure you have ground truth about your network so that you can better answer the questions that are typically asked when doing security operations.

5. *Assess your operation.* You should constantly (or at least periodically) be looking at your defensive plan, comparing it with your latest threat and risk assessments, and asking yourself, "Are we still properly mitigating the risks?" You should test your controls using cases derived from your risk assessment. This verifies that you are correctly mitigating those risks. However, you should also occasionally test your controls against an unconstrained set of threats in order to validate that you are mitigating the correct risks. A good penetration test (pen test) can both verify and validate the controls.

This process can yield a huge number of possible preventive controls. There are some controls, however, that are so pervasive that every information security professional should be able to incorporate them into a defensive architecture. In the following sections, we describe the most important ones.

Firewalls

Firewalls are used to restrict access to one network from another network. Most organizations use firewalls to restrict access to their networks from the Internet. They may also use firewalls to restrict one internal network segment from accessing another internal segment. For example, if the security administrator wants to make sure unauthorized employees cannot access the research and development network, he would place a firewall between the R&D network and all other networks and configure the firewall to allow only the type of traffic he deems acceptable.

A firewall device supports and enforces the organization's network security policy. An organizational security policy provides high-level directives on acceptable and unacceptable actions as they pertain to protecting critical assets. The firewall has a more defined and granular security policy that dictates what services are allowed to be accessed, what IP addresses and ranges are to be restricted, and what ports can be accessed. The firewall is described as a "choke point" in the network because all communications should flow through it, and this is where traffic is inspected and restricted.

A firewall may be a server running a firewall software product or a specialized hardware appliance. In either case, the firewall monitors packets coming into and out of the network it is protecting. It can discard packets, repackage them, or redirect them, depending upon the firewall configuration. Packets are filtered based on their source and destination addresses, and ports by service, packet type, protocol type, header information, sequence bits, and much more. Many times, organizations set up firewalls to construct a *demilitarized zone (DMZ)*, which is a network segment located between the protected and unprotected networks. The DMZ provides a buffer zone between the dangerous Internet and the goodies within the internal network that the organization is trying to protect. As shown in Figure 21-3, two firewalls are usually installed to form the DMZ. The DMZ usually contains web, mail, and DNS servers, which must be hardened systems because they would be the first in line for attacks. Many DMZs also have an IDS sensor that listens for malicious and suspicious behavior.

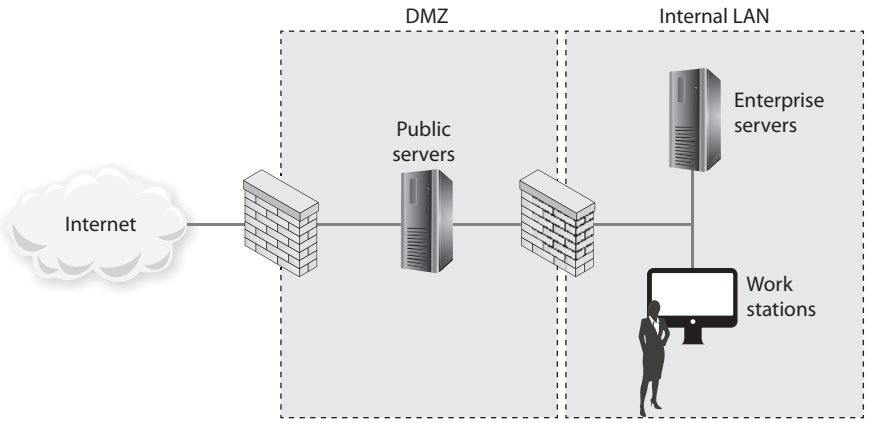


Figure 21-3 At least two firewalls, or firewall interfaces, are generally used to construct a DMZ.

Many different types of firewalls are available, because each environment may have unique requirements and security goals. Firewalls have gone through an evolution of their own and have grown in sophistication and functionality. The following sections describe the various types of firewalls.

The types of firewalls we will review are

- Packet filtering
- Stateful
- Proxy
- Next-generation

We will then dive into the three main firewall architectures, which are

- Screened host
- Multihome
- Screened subnet

NOTE Recall that we discussed another type of firewall, web application firewalls (WAFs), in Chapter 4.

Packet-Filtering Firewalls

Packet filtering is a firewall technology that makes access decisions based upon network-level protocol header values. The device that is carrying out packet-filtering processes is configured with access control lists (ACLs), which dictate the type of traffic that is allowed into and out of specific networks.

Packet filtering was the technology used in the first generation of firewalls, and it is the most rudimentary type of all of the firewall technologies. The filters only have the capability of reviewing protocol header information at the network and transport layers and carrying out permit or deny actions on individual packets. This means the filters can make access decisions based upon the following basic criteria:

- Source and destination IP addresses
- Source and destination port numbers
- Protocol types
- Inbound and outbound traffic direction

Packet filtering is built into a majority of the firewall products today and is a capability that many routers perform. The ACL filtering rules are enforced at the network interface of the device, which is the doorway into or out of a network. As an analogy, you could have a list of items you look for before allowing someone into your office premises through your front door. Your list can indicate that a person must be 18 years or older, have an access badge, and be wearing shoes. When someone knocks on the door, you grab your list, which you will use to decide if this person can or cannot come inside. So your front door is one interface into your office premises. You can also have a list that outlines who can exit your office premises through your back door, which is another interface. As shown in Figure 21-4, a router has individual interfaces with their own unique addresses, which provide doorways into and out of a network. Each interface can have its own ACL values, which indicate what type of traffic is allowed in and out of that specific interface.

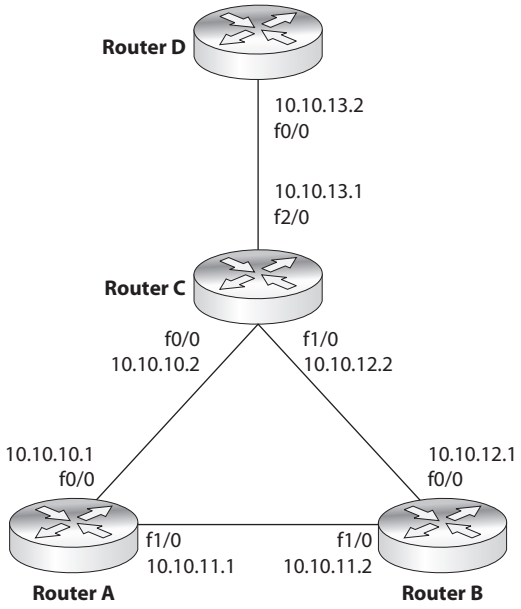


Figure 21-4 ACLs are enforced at the network interface level.

We will cover some basic ACL rules to illustrate how packet filtering is implemented and enforced. The following router configuration allows SMTP traffic to travel from system 10.1.1.2 to system 172.16.1.1:

```
permit tcp host 10.1.1.2 host 172.16.1.1 eq smtp
```

This next rule permits UDP traffic from system 10.1.1.2 to 172.16.1.1:

```
permit udp host 10.1.1.2 host 172.16.1.1
```

If you want to ensure that no ICMP traffic enters through a certain interface, the following ACL can be configured and deployed:

```
deny icmp any any
```

If you want to allow standard web traffic (that is, to a web server listening on port 80) from system 1.1.1.1 to system 5.5.5.5, you can use the following ACL:

```
permit tcp host 1.1.1.1 host 5.5.5.5 eq www
```

NOTE Filtering inbound traffic is known as *ingress filtering*. Outgoing traffic can also be filtered using a process referred to as *egress filtering*.

So when a packet arrives at a packet-filtering device, the device starts at the top of its ACL and compares the packet's characteristics to each rule set. If a successful match (permit or deny) is found, then the remaining rules are not processed. If no matches are found when the device reaches the end of the list, the traffic should be denied, but each product is different. So if you are configuring a packet-filtering device, make sure that if no matches are identified, then the traffic is denied.

Packet filtering is also known as *stateless inspection* because the device does not understand the context that the packets are working within. This means that the device does not have the capability to understand the "full picture" of the communication that is taking place between two systems, but can only focus on individual packet characteristics. As we will see in the next section, stateful firewalls understand and keep track of a full communication session, not just the individual packets that make it up. Stateless firewalls make their decisions for each packet based solely on the data contained in that individual packet.

The lack of sophistication in packet filtering means that an organization should not solely depend upon this type of firewall to protect its infrastructure and assets, but it does not mean that this technology should not be used at all. Packet filtering is commonly carried out at the edge of a network to strip out all of the obvious "junk" traffic. Since the rules are simple and only header information is analyzed, this type of filtering can take place quickly and efficiently. After traffic is passed through a packet-filtering device, it is usually then processed by a more sophisticated firewall, which digs deeper into the packet contents and can identify application-based attacks.

Some of the weaknesses of packet-filtering firewalls are as follows:

- They cannot prevent attacks that employ application-specific vulnerabilities or functions.
- They have limited logging functionality.
- Most packet-filtering firewalls do not support advanced user authentication schemes.
- They may not be able to detect packet fragmentation attacks.

The advantages to using packet-filtering firewalls are that they are scalable, they are not application dependent, and they have high performance because they do not carry out extensive processing on the packets. They are commonly used as the first line of defense to strip out all the network traffic that is obviously malicious or unintended for a specific network. The network traffic usually then has to be processed by more sophisticated firewalls that will identify the not-so-obvious security risks.

Stateful Firewalls

When packet filtering is used, a packet arrives at the firewall, and the firewall runs through its ACLs to determine whether this packet should be allowed or denied. If the packet is allowed, it is passed on to the destination host, or to another network device, and the packet-filtering device forgets about the packet. This is different from stateful inspection, which remembers and keeps track of what packets went where until each particular connection is closed.

A *stateful firewall* is like a nosy neighbor who gets into people's business and conversations. She keeps track of the suspicious cars that come into the neighborhood, who is out of town for the week, and the postman who stays a little too long at the neighbor lady's house. This can be annoying until your house is burglarized. Then you and the police will want to talk to the nosy neighbor, because she knows everything going on in the neighborhood and would be the one most likely to know something unusual happened. A stateful-inspection firewall is nosier than a regular filtering device because it keeps track of what computers say to each other. This requires that the firewall maintain a *state table*, which is like a score sheet of who said what to whom.

Keeping track of the state of a protocol connection requires keeping track of many variables. Most people understand the three-step handshake a TCP connection goes through (SYN, SYN/ACK, ACK), but what does this really mean? If Quincy's system wants to communicate with your system using TCP, it sends your system a packet with the SYN flag value in the TCP header set to 1. This makes this packet a SYN packet. If your system accepts Quincy's system's connection request, it sends back a packet that has both the SYN and ACK flags within the packet header set to 1. This is a SYN/ACK packet. Finally, Quincy's system confirms your system's SYN with its own ACK packet. After this three-way handshake, the TCP connection is established.

While many people know about these three steps of setting up a TCP connection, they are not always familiar with all of the other items that are being negotiated at this time. For example, your system and Quincy's system will agree upon sequence numbers,

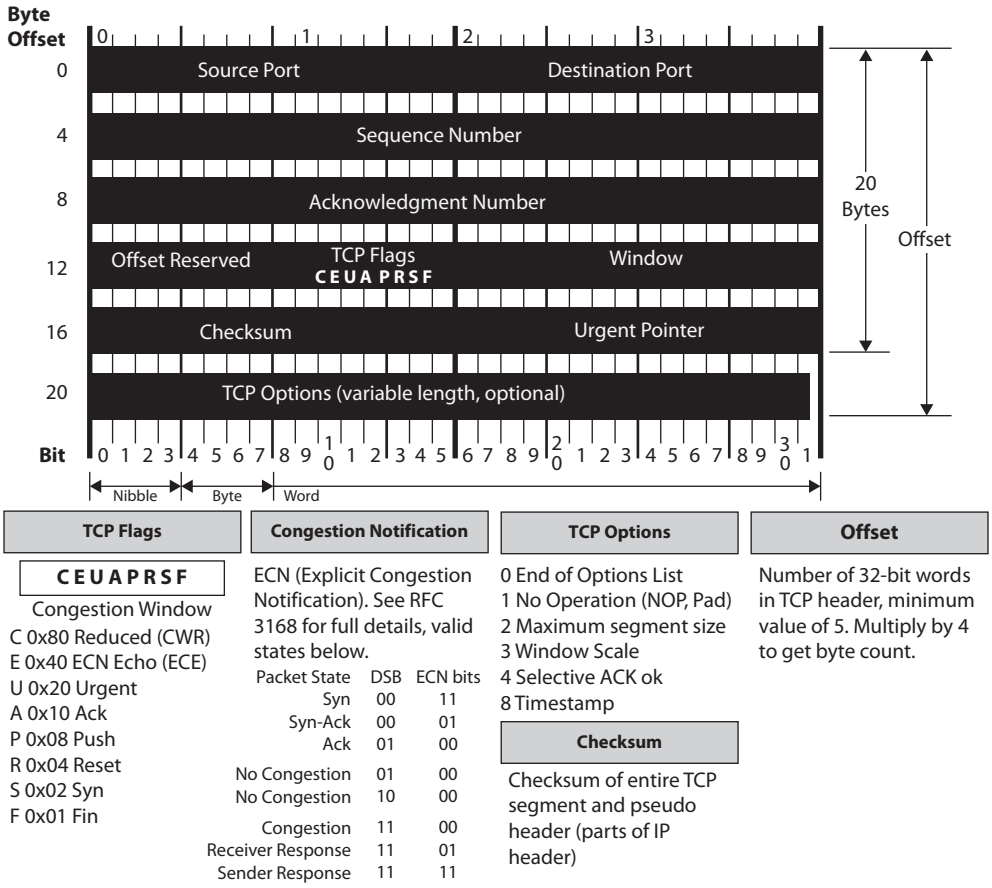


Figure 21-5 TCP header

how much data to send at a time (window size), how potential transmission errors will be identified (CRC values), and so forth. Figure 21-5 shows all of the values that make up a TCP header. So, a lot of information is going back and forth between your systems just in this one protocol—TCP. There are other protocols that are involved with networking that a stateful firewall has to be aware of and keep track of.

So "keeping state of a connection" means to keep a scorecard of all the various protocol header values as packets go back and forth between systems. The values not only have to be correct—they have to happen in the right sequence. For example, if a stateful firewall receives a packet that has all TCP flag values turned to 1, something malicious is taking place. Under no circumstances during a legitimate TCP connection should all of these values be turned on like this. Attackers send packets with all of these values turned to 1 with the hopes that the firewall does not understand or check these values and just forwards the packets onto the target system.

In another situation, if Gwen's system sends your system a SYN/ACK packet and your system did not first send a SYN packet to Gwen's system, this, too, is against the protocol rules. The protocol communication steps have to follow the proper sequence. Attackers send SYN/ACK packets to target systems in an attempt to get the firewall to interpret this as an already established connection and just allow the packets to go to the destination system without inspection. A stateful firewall will not be fooled by such actions because it keeps track of each step of the communication. It knows how protocols are supposed to work, and if something is out of order (incorrect flag values, incorrect sequence, etc.), it does not allow the traffic to pass through.

When a connection begins between two systems, the firewall investigates *all* elements of the packet (all headers, payload, and trailers). All of the necessary information about the specific connection is stored in the state table (source and destination IP addresses, source and destination ports, protocol type, header flags, sequence numbers, timestamps, etc.). Once the initial packets go through this in-depth inspection and everything is deemed safe, the firewall then just reviews the network and transport header portions for the rest of the session. The values of each header for each packet are compared to the values in the current state table, and the table is updated to reflect the progression of the communication process. Scaling down the inspection of the full packet to just the headers for each packet is done to increase performance.

TCP is considered a connection-oriented protocol, and the various steps and states this protocol operates within are very well defined. A connection progresses through a series of states during its lifetime. The states are LISTEN, SYN-SENT, SYN-RECEIVED, ESTABLISHED, FIN-WAIT-1, FIN-WAIT-2, CLOSE-WAIT, CLOSING, LAST-ACK, TIME-WAIT, and the fictional state CLOSED. A stateful firewall keeps track of each of these states for each packet that passes through, along with the corresponding acknowledgment and sequence numbers. If the acknowledgment and/or sequence numbers are out of order, this could imply that a replay attack is underway, and the firewall will protect the internal systems from this activity.

Nothing is ever simple in life, including the standardization of network protocol communication. While the previous statements are true pertaining to the states of a TCP connection, in some situations an application layer protocol has to change these basic steps. For example, FTP uses an unusual communication exchange when initializing its data channel compared to all of the other application layer protocols. FTP basically sets up two sessions just for one communication exchange between two computers. The states of the two individual TCP connections that make up an FTP session can be tracked in the normal fashion, but the state of the FTP connection follows different rules. For a stateful device to be able to properly monitor the traffic of an FTP session, it must be able to take into account the way that FTP uses one outbound connection for the control channel and one inbound connection for the data channel. If you were configuring a stateful firewall, you would need to understand the particulars of some specific protocols to ensure that each is being properly inspected and controlled.

Since TCP is a connection-oriented protocol, it has clearly defined states during the connection establishment, maintenance, and tearing-down stages. UDP is a connectionless protocol, which means that none of these steps take place. UDP holds no state, which makes it harder for a stateful firewall to keep track of. For connectionless protocols,

Stateful-Inspection Firewall Characteristics

The following lists some important characteristics of a stateful-inspection firewall:

- Maintains a state table that tracks each and every communication session
- Provides a high degree of security and does not introduce the performance hit that application proxy firewalls introduce
- Is scalable and transparent to users
- Provides data for tracking connectionless protocols such as UDP and ICMP
- Stores and updates the state and context of the data within the packets

a stateful firewall keeps track of source and destination addresses, UDP header values, and some ACL rules. This connection information is also stored in the state table and tracked. Since the protocol does not have a specific tear-down stage, the firewall will just time out the connection after a period of inactivity and remove the data being kept pertaining to that connection from the state table.

An interesting complexity of stateful firewalls and UDP connections is how ICMP comes into play. Since UDP is connectionless, it does not provide a mechanism to allow the receiving computer to tell the sending computer that data is coming too fast. In TCP, the receiving computer can alter the Window value in its header, which tells the sending computer to reduce the amount of data that is being sent. The message is basically, "You are overwhelming me and I cannot process the amount of data you are sending me. Slow down." UDP does not have a Window value in its header, so instead the receiving computer sends an ICMP packet that provides the same function. But now this means that the stateful firewall must keep track of and allow associated ICMP packets with specific UDP connections. If the firewall does not allow the ICMP packets to get to the sending system, the receiving system could get overwhelmed and crash. This is just one example of the complexity that comes into play when a firewall has to do more than just packet filtering. Although stateful inspection provides an extra step of protection, it also adds more complexity because this device must now keep a dynamic state table and remember connections.

Stateful-inspection firewalls, unfortunately, have been the victims of many types of DoS attacks. Several types of attacks are aimed at flooding the state table with bogus information. The state table is a resource, similar to a system's hard drive space, memory, and CPU. When the state table is stuffed full of bogus information, a poorly designed device may either freeze or reboot.

Proxy Firewalls

A *proxy* is a middleman. It intercepts and inspects messages before delivering them to the intended recipients. Suppose you need to give a box and a message to the president of the United States. You couldn't just walk up to the president and hand over these items.

Instead, you would have to go through a middleman, likely a Secret Service agent, who would accept the box and message and thoroughly inspect the box to ensure nothing dangerous is inside. This is what a proxy firewall does—it accepts messages either entering or leaving a network, inspects them for malicious information, and, when it decides the messages are okay, passes the data on to the destination computer.

A *proxy firewall* stands between a trusted network and an untrusted network and makes the connection, each way, on behalf of the source. What is important is that a proxy firewall breaks the communication channel; there is no *direct* connection between the two communicating devices. Where a packet-filtering device just monitors traffic as it is traversing a network connection, a proxy ends the communication session and restarts it on behalf of the sending system. Figure 21-6 illustrates the steps of a proxy-based firewall. Notice that the firewall does not simply apply ACL rules to the traffic; it stops the user connection at the internal interface of the firewall itself and then starts a new session on behalf of this user on the external interface. When the external web server replies to the request, this reply goes to the external interface of the proxy firewall and ends. The proxy firewall examines the reply information and, if it is deemed safe, starts a new session from itself to the internal system. This is just like our analogy of what the Secret Service agent does between you and the president.

A proxy technology can actually work at different layers of a network stack. A proxy-based firewall that works at the lower layers of the OSI model is referred to as a circuit-level proxy. A proxy-based firewall that works at the application layer is, strangely enough, called an application-level proxy.

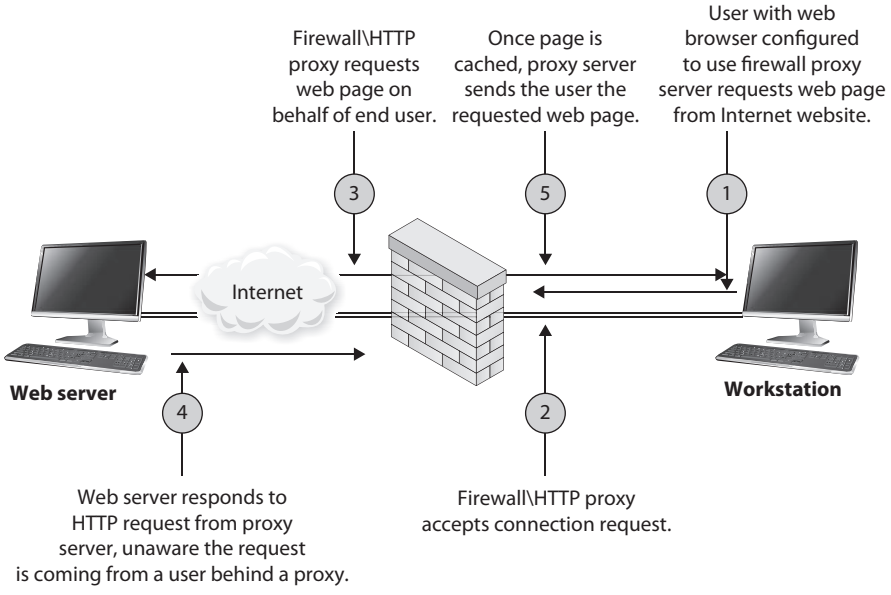


Figure 21-6 Proxy firewall breaks connection

A *circuit-level proxy* creates a connection (circuit) between the two communicating systems. It works at the session layer of the OSI model and monitors traffic from a network-based view. This type of proxy cannot "look into" the contents of a packet; thus, it does not carry out deep-packet inspection. It can only make access decisions based upon protocol header and session information that is available to it. While this means that a circuit-level proxy cannot provide as much protection as an application-level proxy, because it does not have to understand application layer protocols, it is considered application independent. So, it cannot provide the detail-oriented protection that a proxy working at a higher level can, but this allows it to provide a broader range of protection where application layer proxies may not be appropriate or available.

NOTE Traffic sent to the receiving computer through a circuit-level proxy appears to have originated from the firewall instead of the sending system. This is useful for hiding information about the internal computers on the network the firewall is protecting.

Application-level proxies inspect the packet up through the application layer. Where a circuit-level proxy only has insight up to the session layer, an application-level proxy understands the packet as a whole and can make access decisions based on the content of the packets. Application-level proxies understand various services and protocols and the commands that are used by them. An application-level proxy can distinguish between an FTP GET command and an FTP PUT command, for example, and make access decisions based on this granular level of information; on the other hand, packet-filtering firewalls and circuit-level proxies can allow or deny FTP requests only as a whole, not by the commands used within FTP.

An application-level proxy firewall has one proxy per protocol. A computer can have many types of protocols (FTP, NTP, SMTP, HTTP, and so on). Thus, one application-level proxy per protocol is required. This does not mean one proxy firewall per service is required, but rather that one portion of the firewall product is dedicated to understanding how a specific protocol works and how to properly filter it for suspicious data.

Providing application-level proxy protection can be a tricky undertaking. The proxy must totally understand how specific protocols work and what commands within that protocol are legitimate. This is a lot to know and look at during the transmission of data. As an analogy, picture a screening station at an airport that is made up of many employees, all with the job of interviewing people before they are allowed into the airport and onto an airplane. These employees have been trained to ask specific questions and detect suspicious answers and activities, and have the skill set and authority to detain suspicious individuals. Now, suppose each of these employees speaks a different language because the people they interview come from different parts of the world. So, one employee who speaks German could not understand and identify suspicious answers of a person from Italy because they do not speak the same language. This is the same for an application-level proxy firewall. Each proxy is a piece of software that has been designed to understand how a specific protocol "talks" and how to identify suspicious data within a transmission using that protocol.

NOTE If the application-level proxy firewall does not understand a certain protocol or service, it cannot protect this type of communication. In this scenario, a circuit-level proxy is useful because it does not deal with such complex issues. An advantage of a circuit-level proxy is that it can handle a wider variety of protocols and services than an application-level proxy can, but the downfall is that the circuit-level proxy cannot provide the degree of granular control that an application-level proxy provides. Life is just full of compromises.

A circuit-level proxy works similarly to a packet filter in that it makes access decisions based on address, port, and protocol type header values. It looks at the data within the packet header rather than the data at the application layer of the packet. It does not know whether the contents within the packet are safe or unsafe; it only understands the traffic from a network-based view.

An application-level proxy, on the other hand, is dedicated to a particular protocol or service. At least one proxy is used per protocol because one proxy could not properly interpret all the commands of all the protocols coming its way. A circuit-level proxy works at a lower layer of the OSI model and does not require one proxy per protocol because it does not look at such detailed information.

Application-Level Proxy Firewalls

Application-level proxy firewalls, like all technologies, have their pros and cons. It is important to fully understand all characteristics of this type of firewall before purchasing and deploying this type of solution.

Characteristics of application-level proxy firewalls:

- They have extensive logging capabilities due to the firewall being able to examine the entire network packet rather than just the network addresses and ports.
- They are capable of authenticating users directly, as opposed to packet-filtering firewalls and stateful-inspection firewalls, which can usually only carry out system authentication.
- Since they are not simply layer 3 devices, they can address spoofing attacks and other sophisticated attacks.

Disadvantages of using application-level proxy firewalls:

- They are not generally well suited to high-bandwidth or real-time applications.
- They tend to be limited in terms of support for new network applications and protocols.
- They create performance issues because of the necessary per-packet processing requirements.

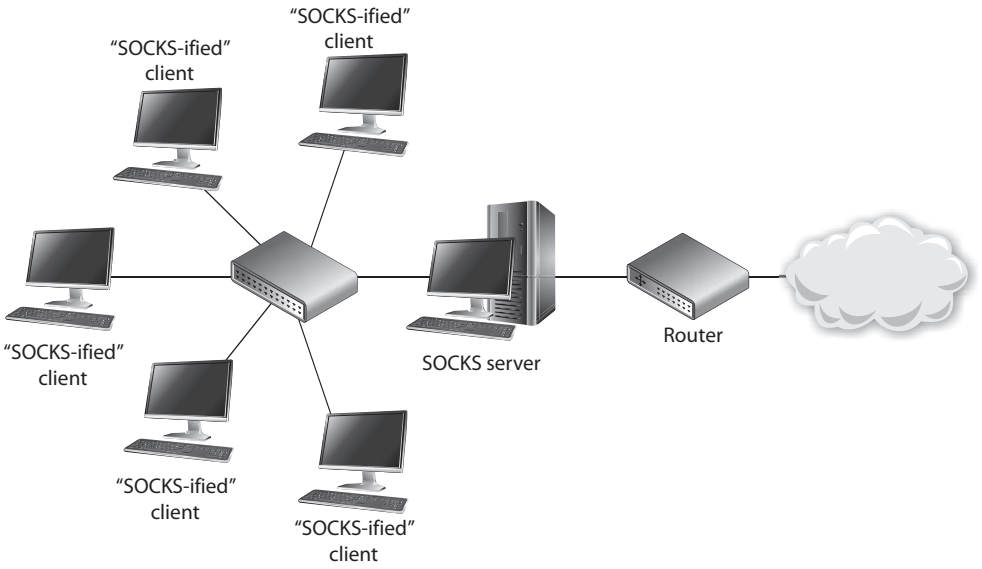


Figure 21-7 Circuit-level proxy firewall

SOCKS is an example of a circuit-level proxy gateway that provides a secure channel between two computers. When a SOCKS-enabled client sends a request to access a computer on the Internet, this request actually goes to the network's SOCKS proxy firewall, as shown in Figure 21-7, which inspects the packets for malicious information and checks its policy rules to see whether this type of connection is allowed. If the packet is acceptable and this type of connection is allowed, the SOCKS firewall sends the message to the destination computer on the Internet. When the computer on the Internet responds, it sends its packets to the SOCKS firewall, which again inspects the data and then passes the packets on to the client computer.

The SOCKS firewall can screen, filter, audit, log, and control data flowing in and out of a protected network. Because of its popularity, many applications and protocols have been configured to work with SOCKS in a manner that takes less configuration on the administrator's part, and various firewall products have integrated SOCKS software to provide circuit-based protection.

NOTE Remember that whether an application- or circuit-level proxy firewall is being used, it is still acting as a proxy. Both types of proxy firewalls deny actual end-to-end connectivity between the source and destination systems. In attempting a remote connection, the client connects to and communicates with the proxy; the proxy, in turn, establishes a connection to the destination system and makes requests to it on the client's behalf. The proxy maintains two independent connections for every one network transmission. It essentially turns a two-party session into a four-party session, with the middle process emulating the two real systems.

Application-Level vs. Circuit-Level Proxy Firewall Characteristics

Characteristics of application-level proxy firewalls:

- Each protocol that is to be monitored must have a unique proxy.
- They provide more protection than circuit-level proxy firewalls.
- They require more processing per packet and thus are slower than circuit-level proxy firewalls.

Characteristics of circuit-level proxy firewalls:

- They do not require a proxy for each and every protocol.
- They do not provide the deep-inspection capabilities of an application-level proxy firewall.
- They provide security for a wider range of protocols.

Next-Generation Firewalls

A *next-generation firewall (NGFW)* combines the best attributes of the previously discussed firewalls, but adds a number of important improvements. Most importantly, it incorporates a signature-based and/or behavioral analysis IPS engine. This means that, in addition to ensuring that the traffic is behaving in accordance with the rules of the applicable protocols, the firewall can look for specific indicators of attack even in otherwise well-behaved traffic. Some of the most advanced NGFWs include features that allow them to share signatures with a cloud-based aggregator so that once a new attack is detected by one firewall, all other firewalls manufactured by that vendor become aware of the attack signature.

Another characteristic of an NGFW is its ability to connect to external data sources such as Active Directory, whitelists, blacklists, and policy servers. This feature allows controls to be defined in one place and pulled by every NGFW on the network, which reduces the chances of inconsistent settings on the various firewalls that typically exist in large networks.

For all their power, NGFWs are not appropriate for every organization. The typical cost of ownership alone tends to make these infeasible for small or even medium-sized networks. Organizations need to ensure that the correct firewall technology is in place to monitor specific network traffic types and protect unique resource types. The firewalls also have to be properly placed; we will cover this topic in the next section.

NOTE Firewall technology has evolved as attack types have evolved. The first-generation firewalls could only monitor network traffic. As attackers moved from just carrying out network-based attacks (DoS, fragmentation, spoofing, etc.) to conducting software-based attacks (buffer overflows, injections, malware, etc.), new generations of firewalls were developed to monitor for these types of attacks.

Firewall Type	OSI Layer	Characteristics
Packet filtering	Network layer	Looks at destination and source addresses, ports, and services requested. Typically routers using ACLs to control and monitor network traffic.
Stateful	Network layer	Looks at the state and context of packets. Keeps track of each conversation using a state table.
Application-level proxy	Application layer	Looks deep into packets and makes granular access control decisions. It requires one proxy per protocol.
Circuit-level proxy	Session layer	Looks only at the header packet information. It protects a wider range of protocols and services than an application-level proxy, but does not provide the detailed level of control available to an application-level proxy.
Next-generation firewall	Multiple layers	Very fast and supportive of high bandwidth. Built-in IPS. Able to connect to external services like Active Directory.

Table 21-1 Comparison of Different Types of Firewalls

Table 21-1 lists the important concepts and characteristics of the firewall types discussed in the preceding sections. Although various firewall products can provide a mix of these services and work at different layers of the OSI model, it is important you understand the basic definitions and functionalities of these firewall types.

Appliances

A firewall may take the form of either software installed on a regular computer using a regular operating system or a dedicated hardware appliance that has its own operating system. The second choice is usually more secure, because the vendor uses a stripped-down version of an operating system (usually Linux or BSD Unix). Operating systems are full of code and functionality that are not necessary for a firewall. This extra complexity opens the doors for vulnerabilities. If a hacker can exploit and bring down a company's firewall, then the company is very exposed and in danger.

In today's jargon, dedicated hardware devices that have stripped-down operating systems and limited and focused software capabilities are called *appliances*. Where an operating system has to provide a vast array of functionality, an appliance provides very focused functionality—as in just being a firewall.

If a software-based firewall is going to run on a regular system, then the unnecessary user accounts should be disabled, unnecessary services deactivated, unused subsystems disabled, unneeded ports closed, and so on. If firewall software is going to run on a regular system and not a dedicated appliance, then the system needs to be fully locked down.

Firewall Architecture

Firewalls can be placed in a number of areas on a network to meet particular needs. They can protect an internal network from an external network and act as a choke point for all traffic. A firewall can be used to segment and partition network sections and enforce access controls between two or more subnets. Firewalls can also be used to provide a DMZ architecture. And as covered in the previous section, the right firewall type needs to be placed in the right location. Organizations have common needs for firewalls; hence, they keep them in similar places on their networks. We will see more on this topic in the following sections.

Dual-Homed Firewall *Dual-homed* refers to a device that has two interfaces: one connected to one network and the other connected to a different network. If firewall software is installed on a dual-homed device—and it usually is—the underlying operating system should have packet forwarding and routing turned off for security reasons. If they are enabled, the computer may not apply the necessary ACLs, rules, or other restrictions required of a firewall. When a packet comes to the external NIC from an untrusted network on a dual-homed firewall and the operating system has forwarding enabled, the operating system forwards the traffic instead of passing it up to the firewall software for inspection.

Many network devices today are *multihomed*, which just means they have several NICs that are used to connect several different networks. Multihomed devices are commonly used to house firewall software, since the job of a firewall is to control the traffic as it goes from one network to another. A common multihomed firewall architecture allows an organization to have several DMZs. One DMZ may hold devices that are shared between organizations in an extranet, another DMZ may house the organization's DNS and mail servers, and yet another DMZ may hold the organization's web servers. Different DMZs are used for two reasons: to control the different traffic types (for example, to ensure HTTP traffic only goes toward the web servers and ensure DNS requests go toward the DNS server), and to ensure that if one system on one DMZ is compromised, the other systems in the rest of the DMZs are not accessible to this attacker.

If a company depends solely upon a multihomed firewall with no redundancy, this system could prove to be a single point of failure. If it goes down, then all traffic flow stops. Some firewall products have embedded redundancy or fault-tolerance capabilities. If a company uses a firewall product that does not have these capabilities, then the network should have redundancy built into it.

Along with potentially being a single point of failure, another security issue that is posed by relying on a single firewall is the lack of defense in depth. If the company depends on just one firewall, no matter what architecture is being used or how many interfaces the device has, there is only one layer of protection. If an attacker can compromise the one firewall, then she can gain direct access to company network resources.

Screened Host A *screened host* is a firewall that communicates directly with a perimeter router and the internal network. Figure 21-8 shows this type of architecture.

Traffic received from the Internet is first filtered via packet filtering on the outer router. The traffic that makes it past this phase is sent to the screened-host firewall, which applies