CHAPTER 19

Measuring Security

This chapter presents the following:

- Security metrics
- Security process data
- Reporting
- Management review and approval

One accurate measurement is worth a thousand expert opinions.

—Grace Hopper

The reason we conduct security assessments is that we want to answer specific questions. Is the firewall blocking dangerous traffic? How many systems are vulnerable? Can we detect (and block) phishing attacks? (The list goes on.) These questions all are important but also are very tactical. The typical board of directors or C-suite won't understand or care about them. What they do care about is how the organization is generating value for its stakeholders. Part of our job as cybersecurity leaders is to turn tactical observations into strategic insights. To do this, we need to be able to measure the right parts of our information security management system (ISMS) over time, analyze the results, and present them in an actionable manner to other leaders in our organizations. This is what this chapter is all about.

Quantifying Security

How can you tell whether you are moving toward or away from your destination? In the physical world, we use all sorts of environmental cues such as road signs and landmarks. Oftentimes, we can also use visual cues to assess the likely risk in our travels. For instance, if a sign on a hiking trail is loose and can pivot around its pole, then we know that there is a chance that the direction in which it points is not the right one. If a landmark is a river crossing and the waters are much higher than normal, we know we run the risk of being swept downstream. But when it comes to our security posture, how can we tell whether we're making progress and whether we're taking risks?

Attempting to run an ISMS without adequate metrics is perhaps more dangerous than not managing security at all. The reason is that, like following misplaced trail signs, using the wrong metrics can lead the organization down the wrong path and result in worse outcomes than would be seen if all is left to chance. Fortunately, the International Organization for Standardization (ISO) has published an industry standard for developing and using metrics that measure the effectiveness of a security program. ISO/IEC 27004, *Information security management — Monitoring, measurement, analysis and evaluation*, outlines a process by which to measure the performance of security controls and processes. Keep in mind that a key purpose of this standard is to support continuous improvement in an organization's security posture.

At this point, it is helpful to define a handful of terms:

- **Factor** An attribute of a system (such as an ISMS) that has a value that can change over time. Examples of factors are the number of alerts generated by an intrusion detection system (IDS) or the number of events investigated by the incident response (IR) team.
- **Measurement** A quantitative observation of a factor at a particular point in time. In other words, this is raw data. Two examples of measurements would be 356 IDS alerts in the last 24 hours and 42 verified events investigated by the IR team in the month of January.
- **Baseline** A value for a factor that provides a point of reference or denotes that some condition is met by achieving some threshold. For example, a baseline could be the historic trend in the number of IDS alerts over the past 12 months (a reference line) or a goal that the IR team will investigate 100 events or less in any given month (a threshold value).
- **Metric** A derived value that is generated by comparing multiple measurements against each other or against a baseline. Metrics are, by their very nature, comparative. Building upon the previous examples, an effective metric could be the ratio of verified incidents to IDS alerts during a 30-day period.
- **Indicator** A particularly important metric that describes a key element of the effectiveness of a system (such as an ISMS). In other words, indicators are meaningful to business leaders. If one of management's goals is to minimize the number of high-severity incidents, then an indicator could be the ratio of such incidents declared during a reporting period compared to an established baseline.

To put this all together visually, Figure 19-1 shows the relationship between these terms. Suppose you have a bunch of processes that make up your ISMS but there are two factors that are particularly important for you to track. Let's call them Factor A and Factor B, which could be anything, but for this hypothetical scenario, assume that they are network detection and response (NDR) system alerts and incidents declared. You intend to periodically take measurements for these factors, and the very first time you do so you get measurements A1 (say, 42 alerts) and B1 (7 incidents). You compare these measurements to each other and get your first metric A1:B1, which is the ratio of alerts generated to incidents declared (in this case, six). This metric might tell you how well tuned your NDR solution is; the higher the metric, the higher the number of false positives you're having to track down and, therefore, the less efficient your time is spent.

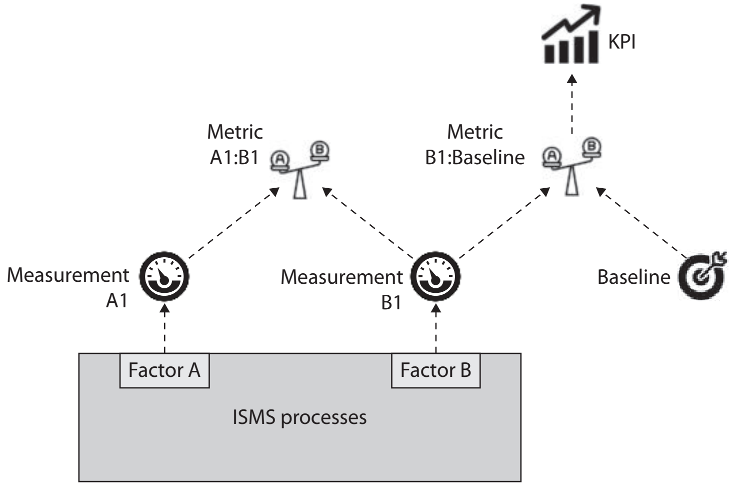


Figure 19-1 Relationship between factors, measurements, baselines, metrics, and KPIs

The second metric is a bit different. It is the comparison of B1 (the measurement of incidents) to some baseline you've established. Assume that management has determined that anything over five incidents per reporting period is a bad thing and might show that either your risk assessment is off (i.e., the threat is higher than you thought) or your ISMS is not doing well (i.e., your controls are not working as you need them to). This metric is particularly important to tracking your strategic business goals and thus becomes a key performance indicator (KPI). KPIs are discussed a bit later in this section.

Security Metrics

Security metrics sometimes get a bad reputation as tedious, burdensome, or even irrelevant. Many organizations pay lip service to them by latching on to the simple things that can easily be measured, such as the number of open tickets or how long it takes analysts to close each ticket. The problem with this approach is that it doesn't really generate valuable insights into how we are doing and how can we do better. In fact, if we measure the wrong things, we can end up doing more harm than good. For example, plenty of organizations rate their analysts based on how many tickets they close in a shift. This approach incentivizes throughput rather than careful analysis and oftentimes leads to missing evidence of ongoing attacks.

The best information security professionals use metrics to tell stories and, like any good storyteller, know their audience. What metrics we need and how we link them together depends on both the story we want to tell and the people to whom we'll be telling it. Board members typically like to hear about strategic threats and opportunities for the organization. Business managers may want to know how protected their business units are. Security operations leaders usually are most interested in how their teams are performing. In order to effectively engage each of these audiences, you need a different type of security metric.

Before we dive into the different types of metrics, it is important to identify what makes a good security metric in the first place. There are six characteristics of a good metric that you should consider:

- **Relevant** Does it align with your goals? Is it correlated with improved outcomes? The metric should be directly tied to your security goals and indirectly tied to your organization's business goals.
- **Quantifiable** Can it be objectively measured in a consistent manner? Could someone game it? A good metric should be relatively easy to measure with the tools at your disposal.
- **Actionable** Can you do something with it? Does it tell you what you must do to make things better? The best metrics inform your immediate actions, justify your requests, and directly lead to improved outcomes.
- **Robust** Will it be relevant in a year? Can you track it over many years? A good metric must allow you to track your situation over time to detect trends. It should capture information whose value endures.
- **Simple** Does it make intuitive sense? Will all stakeholders "get it?" Will they know what was measured and why it matters to them? If you can't explain the metric in a simple sentence, it probably is not a good one.
- **Comparative** Can it be evaluated against something else? Good metrics are the result of comparing measurements to each other or to some baseline or standard. This is why the best metrics are ratios, or percentages, or changes over time.

NOTE Another commonly used approach is to ensure metrics are SMART (specific, measurable, achievable, relevant, and time-bound).

Risk Metrics

Risk metrics capture the organizational risk and how it is changing over time. These are the metrics you're most likely to use if you are communicating with an executive audience, because these metrics are not technical. They are also forward-looking because they address things that may happen in the future. For these reasons, risk metrics are the best ones to support strategic analyses.

Depending on your organization's risk management program, you may already have risk metrics defined. Recall from Chapter 2 that quantitative risk management requires that you identify and capture risk metrics. Even if you use a qualitative approach, you probably have a good place from which to start. All you have to do is identify the variables that make your risks more or less likely to be realized and then start tracking those. Here are some examples of commonly used risk metrics:

- The percentage of change in your aggregated residual risks
- The percentage of change in your current worst-case risk
- The ratio of organizational security incidents to those reported by comparable organizations

Preparedness Metrics

There is another type of metric that indicates how prepared your organization is to deal with security incidents. These metrics are sometimes useful when dealing with executives, but they are more commonly used to monitor the security program as a whole. Preparedness metrics look at all your controls and how well they are being maintained. For example, are your policies and procedures being followed? Do your staff members know what they're supposed to (and not supposed to) do? What about your business partners?

Given the importance (and difficulty) of securing your organization's supply chain, your preparedness metrics should include the preparedness of organizations that are upstream from yours (in other words, your organization's suppliers of goods and services). Depending on your organization's relationship with them, you may have a lot of visibility into their security programs, which makes your assessment and measuring of them a lot easier. Even if they are fairly opaque and unwilling to give you enough information, you should develop a mechanism for rating their security, perhaps using an external or third-party audit, as discussed in Chapter 18.

Here are some examples of preparedness metrics used by many organizations:

- Monthly change in the mean time to patch a system
- Percentage of systems that are fully patched
- Percentage of staff that is up to date on security awareness training
- Ratio of privileged accounts to nonprivileged accounts
- Annual change in vendor security rating (i.e., how prepared is your organization's supply chain)

Performance Metrics

If risk metrics are fairly strategic and preparedness metrics are more operational, performance metrics are as tactical as they come. They measure how good your team and systems are at detecting, blocking, and responding to security incidents. In other words, performance metrics tell you how good you are at defeating your adversaries day in and day out.

If you've ever worked in or led a security operations center, performance metrics are the metrics you're probably most used to seeing. Some examples are listed here:

- Number of alerts analyzed this week/month compared to last week/month
- Number of security incidents declared this week/month compared to last week/month
- Percent change in mean time to detect (MTTD)
- Percent change in mean time to resolve (MTTR)

Key Performance and Risk Indicators

There is no shortage of security metrics in the industry, but not all are created equal. There are some that are important for tracking our processes and day-to-day operations. Other metrics, however, can tell us whether or not we are meeting strategic business goals.

These are the key performance indicators (KPIs) and key risk indicators (KRIs). KPIs measure how well things are going now, while KRIs measure how badly things could go in the future.

Key Performance Indicators

A *key performance indicator* is an indicator that is particularly significant in showing the performance of an ISMS compared to its stated goals. KPIs are carefully chosen from among a larger pool of indicators to show at a high level whether our ISMS is keeping pace with the threats to our organization or showing decreased effectiveness. KPIs should be easily understood by business and technical personnel alike and should be aligned with one or (better yet) multiple organizational goals.

Choosing KPIs really forces us to wrestle with the question "What is it that we're trying to accomplish here?" The process by which we choose KPIs is really driven by organizational goals. In an ideal case, the senior leadership sets (or perhaps approves) goals for the security of the organization. The ISMS team then gets to work on how to show whether we are moving toward or away from those goals. The process can be summarized as follows:

1. Choose the factors that can show the state of our security. In doing this, we want to strike a balance between the number of data sources and the resources required to capture all their data.
2. Define baselines for some or all of the factors under consideration. As we do this, it is helpful to consider which measurements will be compared to each other and which to some baseline. Keep in mind that a given baseline may apply to multiple factors' measurements.
3. Develop a plan for periodically capturing the values of these factors, and fix the sampling period. Ideally, we use automated means of gathering this data so as to ensure the periodicity and consistency of the process.
4. Analyze and interpret the data. While some analysis can (and probably should) be automated, there will be situations that require human involvement. In some cases, we'll be able to take the data at face value, while in others we will have to dig into it and get more information before reaching a conclusion about it.
5. Communicate the indicators to all stakeholders. In the end, we need to package the findings in a way that is understandable by a broad range of stakeholders. A common approach is to start with a nontechnical summary that is supported by increasingly detailed layers of supporting technical information. On the summary side of this continuum is where we select and put our KPIs.

This process is not universally accepted but represents some best security industry practices. At the end of the day, the KPIs are the product of distilling a large amount of information with the goal of answering one specific question: "Are we managing our information security well enough?" There is no such thing as perfect security, so what we are really trying to do is find the sweet spot where the performance of the ISMS is adequate and sustainable using an acceptable amount of resources. Clearly, this spot is a moving target given the ever-changing threat and risk landscape.

Key Risk Indicators

While KPIs tell us where we are today with regard to our goals, *key risk indicators* tell us where we are today in relation to our risk appetite. They measure how risky an activity is so that leadership can make informed decisions about that activity, all the while taking into account potential resource losses. Like KPIs, KRIs are selected for their impact on the decisions of the senior leaders in the organization. This means that KRIs often are not specific to one department or business function, but rather affect multiple aspects of the organization. KRIs have, by definition, a very high business impact.

When considering KRIs, it is useful to relate them to single loss expectancy (SLE) equations. Recall from Chapter 2 that SLE is the organization's potential monetary loss if a specific threat were to be realized. It is the product of the loss and the likelihood that the threat will occur. In other words, if we have a proprietary process for building widgets valued at $500,000 and we estimate a 5 percent chance of an attacker stealing and monetizing that process, then our SLE would be $25,000. Now, clearly, that 5 percent figure is affected by a variety of activities within the organization, such as IDS tuning, IR team proficiency, and end-user security awareness.

Over time, the likelihood of the threat being realized will change based on multiple activities going on within the organization. As this value changes, the risk changes too. A KRI would capture this and allow us to notice when we have crossed a threshold that makes our current activities too risky for our stated risk appetite. This trigger condition enables the organization to change its behavior to compensate for excessive risk. For instance, it could trigger an organizational stand-down for security awareness training.

In the end, the important thing to remember about KRIs is that they are designed to work much as coal mine canaries: they alert us when something bad is likely to happen so that we can change our behavior and defeat the threat.

EXAM TIP KPIs and KRIs are used to measure progress toward attainment of strategic business goals.

Security Process Data

Most of our metrics and indicators come from the security processes that make up our ISMS. There are other sources of measures, of course, but if we want to assess the effectiveness of our security controls, clearly we have to look at them first. To determine whether our controls are up to speed, we need to collect security process data from a variety of places. From how we manage our accounts to how we verify backups to the security awareness of our employees, administrative controls are probably more pervasive and less visible than our technical controls. It shouldn't be surprising that sophisticated threat actors often try to exploit administrative controls.

We covered a number of technical processes in the previous chapter. These included vulnerability assessments, various forms of attack simulations, and log reviews, to name a few. In the sections that follow, we look at some of the more administrative processes from which we can also collect data to help us determine our current posture and help us improve it over time. This is by no means an exhaustive list; it is simply a sampling that $(ISC)^2$ emphasizes in the CISSP exam objectives.

Account Management

A preferred technique of attackers is to become "normal" privileged users of the systems they compromise as soon as possible. They can accomplish this in at least three ways: compromise an existing privileged account, create a new privileged account, or elevate the privileges of a regular user account. The first approach can be mitigated through the use of strong authentication (e.g., strong passwords or, better yet, multifactor authentication) and by having administrators use privileged accounts only for specific tasks. The second and third approaches can be mitigated by paying close attention to the creation, modification, or misuse of user accounts. These controls all fall in the category of *account management*.

Adding Accounts

When new employees arrive, they should be led through a well-defined process that is aimed at ensuring not only that they understand their duties and responsibilities, but also that they are assigned the required organizational assets and that these are properly configured, protected, and accounted for. While the specifics of how this is accomplished vary from organization to organization, there are some specific administrative controls that should be universal.

First, all new users should be required to read through and acknowledge they understand (typically by signing) all policies that apply to them. At a minimum, every organization should have (and every user should sign) an acceptable use policy (AUP) that specifies what the organization considers acceptable use of the information systems that are made available to the employee. Using a workplace computer to view pornography, send hate e-mail, or hack other computers is almost always specifically forbidden in the AUP. On the other hand, many organizations allow their employees limited personal use, such as checking personal e-mail or surfing the Web during breaks. The AUP is a useful first line of defense, because it documents when each user was made aware of what is and is not acceptable use of computers (and other resources) at work. This makes it more difficult for a user to claim ignorance if they subsequently violate the AUP.

Testing that all employees are aware of the AUP and other applicable policies can be the first step in auditing user accounts. Since every user should have a signed AUP, for instance, all we need is to get a list of all users in the organization and then compare it to the files containing the signed documents. In many cases, all the documents a new employee signs are maintained by human resources (HR) and the computer accounts are maintained by IT. Cross-checking AUPs and user accounts can also verify that these two departments are communicating effectively.

The policies also should dictate the default expiration date of accounts, the password policy, and the information to which a user should have access. This last part becomes difficult because the information needs of individual users typically vary over time.

Modifying Accounts

Suppose a newly hired IT technician is initially assigned the task of managing backups for a set of servers. Over time, you realize this individual is best suited for internal user support, including adding new accounts, resetting passwords, and so forth. The privileges needed in each role are clearly different, so how should you handle this? Many organizations, unfortunately, resort to giving all privileges that a user may need. We have all been in, seen, or heard of organizations where every user is a local admin on his or her computer and every member of the IT department is a domain admin. This is an exceptionally dangerous practice, especially if they all use these elevated credentials by default. This is often referred to as *authorization creep*, which we discussed in Chapter 17.

Adding, removing, or modifying the permissions that a user has should be a carefully controlled and documented process. When are the new permissions effective? Why are they needed? Who authorized the change? Organizations that are mature in their security processes have a change control process in place to address user privileges. While many auditors focus on who has administrative privileges in the organization, there are many custom sets of permissions that approach the level of an admin account. It is important, then, to have and test processes by which elevated privileges are issued.

The Problem with Running as Root

It is undoubtedly easier to do all your work from one user account, especially if that account has all the privileges you could ever need. The catch, as you may well know, is that if your account is compromised, the malicious processes will run with whatever privileges the account has. If you run as root (or admin) all the time, you can be certain that if an attacker compromises your box, he instantly has the privileges to do whatever he needs or wants to do.

A better approach is to do as much of your daily work as you can using a restricted account and elevate to a privileged account only when you must. The way in which you do this varies by operating system:

- Windows operating systems allow you to right-click any program and select Run As to elevate your privileges. From the command prompt, you can use the command `runas /user:<AccountName>` to accomplish the same goal.
- In Linux operating systems, you can simply type `sudo<SomeCommand>` at the command line to run a program as the super (or root) user. Some Linux GUI desktop environments also offer the user the option of running with sudo (usually by checking a box) and prompting for a password.
- In macOS, you use `sudo` from the Terminal app just like you would do from a Linux terminal. However, if you want to run a GUI app with elevated privileges, you need to use `sudo open -a <AppName>` since there is no `gksudo` or `kdesudo` command.

PART VI

Suspending Accounts

Another important practice in account management is to suspend accounts that are no longer needed. Every large organization eventually stumbles across one or more accounts that belong to users who are no longer part of the organization. In extreme cases, an organization discovers that a user who left several months ago still has privileged accounts. The unfettered presence of these accounts on our networks gives adversaries a powerful means to become seemingly legitimate users, which makes our job of detecting and repulsing them that much more difficult.

Accounts may become unneeded, and thus require suspension, for a variety of reasons, but perhaps the most common one would be that the user of the account was terminated or otherwise left the organization. Other reasons for suspension include reaching the account's default expiration date, and temporary, but extended, absences of employees (e.g., maternity leave, military deployment). Whatever the reason, we must ensure that the account of someone who is not present to use it is suspended until that person returns or the term of our retention policy is met.

Testing the administrative controls on suspended accounts follows the same pattern already laid out in the preceding two sections: look at each account (or take a representative sample of all of them) and compare it with the status of its owner according to our HR records. Alternatively, we can get a list of employees who are temporarily or permanently away from the organization and check the status of those accounts. It is important that accounts are deleted only in strict accordance with the data retention policy. Many investigations into terminated employees have been thwarted because administrators have prematurely deleted user accounts and/or files.

Backup Verification

Modern organizations deal with vast amounts of data, which must be protected for a variety of reasons, including disaster recovery. We have all been in at least one situation in which we have lost data and needed to get it back. Some of us have had a rude awakening upon discovering that the data was lost permanently. The specific nature of the backup media is not as important as the fact that the data must be available when we need it most.

Magnetic tapes are now able to hold over 180 terabytes of data, which makes this seemingly antiquated technology the best in terms of total cost of ownership. That being said, many organizations prefer other technologies for daily operations, and relegate tapes to the role of backup to the backup. In other words, it is not uncommon for an organization to back up its user and enterprise data to a storage area network (SAN) on a daily basis, and back up these backups to tape on a weekly basis. Obviously, the frequency of each backup (hourly, daily, weekly) is driven by the risk management process discussed in Chapter 1.

Whatever the approach to backing up our organizational data, we need to periodically test it to ensure that the backups will work as promised when we need them. There are some organizations that have faced an event or disaster that required them to restore some or all data from backups, only to discover that the backups were missing, corrupted, or outdated. This section discusses some approaches to assess whether the data will be there when we need it.

CAUTION Never back up your data to the same device on which the original data exists.

Types of Data

Not all data is created equal, and different types may have unique requirements when it comes to backups. The following sections discuss some of the major categories of data that most of us deal with and some considerations when planning to preserve that data. Keep in mind, however, that there are many other types of data that we will not discuss here for the sake of brevity.

User Data Files This is the type of data with which most of us are familiar. These are the documents, presentations, and spreadsheets that we create or use on a daily basis. Though backing up these files may seem simple, challenges arise when users put "backup" copies in multiple locations for safekeeping. Users, if left to their own devices, may very well end up with inconsistently preserved files and may even violate retention requirements. The challenge with this type of data is ensuring that it is consistently backed up in accordance with all applicable policies, regulations, and laws.

Databases Databases are different from regular files in that they typically store the entire database in a special file that has its own file system within it. To make sense of this embedded file system, your database software uses metadata that lives in other files within your system. This architecture can create complex interdependencies among files on the database server. Fortunately, all major database management systems (DBMSs) include one or more means to back up their databases. The challenge is in ensuring that the backup will be sufficient to reconstitute the databases if necessary. To verify the backups, many organizations use a test database server that is periodically used to verify that the databases can be recovered from backup and that the queries will execute properly from the restored data.

Virtualization as a Backup and Security Strategy

Many organizations have virtualized their server infrastructure for performance and maintenance reasons. Some are also virtualizing their client systems and turning their workstations into thin clients on a virtualization infrastructure. The next step in this evolution is the use of virtual machine (VM) snapshots as a backup strategy. The main advantage to this approach is that restoration is almost instantaneous. All you typically have to do is click a button or issue a scripted command and the VM will revert to the designated state. Another key advantage is that this approach lends itself to automation and integration with other security systems so that if, for example, a workstation is compromised because the user clicked a link and an IDS detected this incident, then the VM can be instantly quarantined for later analysis while the user is dropped into the most recent snapshot automatically with very little impact to productivity.

Mailbox Data By some estimates, as much as 75 percent of an average organization's data lives in its mailboxes. Depending on the mail system your organization is running, the backup process may be very different. Still, some commonalities exist across all platforms, such as the critical need to document in excruciating detail every aspect of the configuration of the mail servers. Most medium-sized to large organizations have multiple mail servers (perhaps backing each other up), so it is a good idea not to back them up at the same time. Finally, whatever backup mechanism you have in place for your mail servers should facilitate compliance with e-discovery.

Verification

Having data backups is not particularly helpful unless we are able to use them to recover from mistakes, accidents, attacks, or disasters. Central to verifying this capability is understanding the sorts of things that can go wrong and which of them would require backups. Recall from our discussion on threat modeling in Chapter 9 that an important step in understanding risk is to consider what can happen or be done to our systems that would destroy, degrade, or disrupt our ability to operate. It is helpful to capture these possibilities in scenarios that can then inform how we go about ensuring that we are prepared for the likely threats to our information systems. It is also helpful to automate as much of the testing as possible, particularly in large organizations. This ensures that we cover the likely contingencies in a very methodical and predictable manner.

Some tests may cause disruptions to our business processes. It is difficult to imagine how a user's backups can be fully tested without involving that user in the process to some extent. If, for instance, our users store files locally and we want to test Mary's workstation backup, an approach could be to restore her backup to a new computer and have Mary log into and use the new computer as if it were the original. She would be in a better position than anyone else to determine whether everything works as expected. This kind of thorough testing is expensive and disruptive, but it ensures that we have in place what we need. Obviously, we have to be very selective about when and how we impact our business processes, so it becomes a trade-off.

However you decide to implement your backup verification, you must ensure that you are able to assert that all critical data is backed up and that you will be able to restore it in time of need. This means that you probably have to develop an inventory of data and a schedule for testing it as part of your plan. This inventory will be a living document, so you must have a means to track and document changes to it. Fortunately, major items such as mail and database servers don't change very frequently. The challenge is in verifying the backups of user data.

This brings us back to our policies. We already discussed the importance of the organization's data retention policy, but an equally important one is the policy that dictates how user data is backed up. Many organizations require their staff to maintain their files on file shares on network servers, but we all know that users don't necessarily always do this. It is not uncommon for users to keep a local folder with the data that is most important to them. If the local files are not being backed up, then we risk losing the most critical files, particularly if backups can be disabled by the user. The point of this is that policies need to be carefully thought out and aggressively enforced if we are to be ready for the day when things go badly for us.

Testing Data Backups

It is important to develop formal processes for testing your data backups to ensure they are available when needed. The following are some elements that should be included in these processes:

- *Develop scenarios* that capture specific sets of events that are representative of the threats facing the organization.
- *Develop a plan* that tests all the mission-critical data backups in each of the scenarios.
- *Leverage automation* to minimize the effort required by the auditors and ensure tests happen periodically.
- *Minimize impact on business* processes of the data backup test plan so that it can be executed regularly.
- *Ensure coverage* so that every system is tested, though not necessarily in the same test.
- *Document the results* so you know what is working and what needs to be worked on.
- *Fix or improve* any issues you documented.

Security Training and Security Awareness Training

As should be clear from the preceding discussions, having a staff that is well trained in security issues is crucial to the security of our organizations. The terms security training and security awareness training are often used interchangeably, but they have subtly different meanings. *Security training* is the process of teaching a skill or set of skills that enables people to perform specific security functions better. *Security awareness training*, on the other hand, is the process of exposing people to security issues so that they are able to recognize and respond to them better. Security training is typically provided to security personnel, while security awareness training should be provided to every member of the organization.

Assessing the effectiveness of our security training programs is fairly straightforward because the training is tied to specific security functions. Therefore, to test the effectiveness of a training program, all we have to do is test the performance of an individual on those functions before and after the training. If the performance improves, then the training was probably effective. Keep in mind that skills atrophy over time, so the effectiveness of the training should be measured immediately after it concludes. Otherwise, we are assessing the long-term retention of the functional skills.

We now turn our attention to the somewhat more difficult issue of assessing the effectiveness of a security awareness training program. As we broach this subject, keep in mind that the end state is to better equip our teammates to recognize and deal with security issues that arise while they are performing their everyday tasks. This implies that a key measure of the effectiveness of the security awareness program is the degree to which people change their behaviors when presented with certain situations. If this change is toward a better security posture, then we can infer that the program was effective. In the following sections, we take a look at specific components of a security awareness training program that are common to many organizations.

EXAM TIP Security awareness (and the training required to attain it) is one of the most critical controls in any ISMS. Expect exam questions on this topic.

Social Engineering

Social engineering, in the context of information security, is the process of manipulating individuals so that they perform actions that violate security protocols. Whether the action is divulging a password, letting someone into the building, or simply clicking a link, it has been carefully designed by the adversaries to help them exploit our information systems. A common misconception is that social engineering is an art of improvisation. While improvising may help the attacker better respond to challenges, the reality is that most effective social engineering is painstakingly designed against a particular target, sometimes a specific individual.

Perhaps the most popular form of social engineering is *phishing*, which is social engineering conducted through a digital communication. Figure 19-2 depicts the flow of a typical e-mail phishing attack. (While e-mail phishing receives a lot of attention, text messages can also be used to similar effect.) Like casting a baited fishing line into a

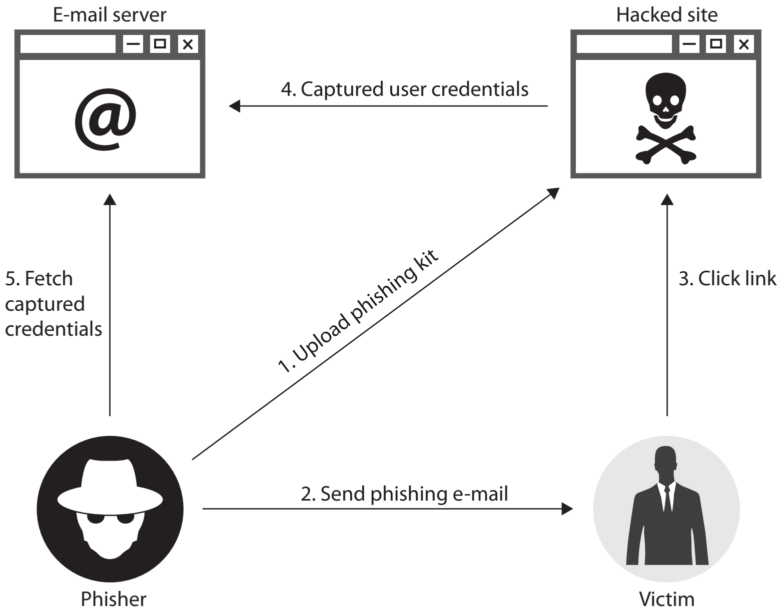


Figure 19-2 Typical phishing attack

pond full of fish, phishing relies on the odds that if enough people receive an enticing or believable message, at least one of them will click an embedded link within it.

Some adversaries target specific individuals or groups, which is referred to as *spear-phishing*. In some cases, the targets are senior executives, in which case it is called *whaling*. In whatever variety it comes, the desired result of phishing is usually to have the target click a link that will take them to a website under the control of the attacker. Sometimes the website looks like the legitimate logon page of a trusted site, such as that of the user's bank. Other times, the website is a legitimate one that has been compromised by the attacker to redirect users somewhere else. In the case of a *drive-by download*, the site invisibly redirects the user to a malware distribution server, as shown in Figure 19-3.

Pretexting is a form of social engineering, typically practiced in person or over the phone, in which the attacker invents a believable scenario in an effort to persuade the target to violate a security policy. A common example is a call received from (allegedly) customer service or fraud prevention at a bank in which the attacker tries to get the target to reveal account numbers, personal identification numbers (PINs), passwords, or similarly valuable information. Remarkably, pretexting was legal in the United States until 2007, as long as it was not used to obtain financial records. In 2006, Hewlett-Packard became embroiled in a scandal dealing with its use of pretexting in an effort to identify the sources of leaks on its board of directors. Congress responded by passing the Telephone Records and Privacy Protection Act of 2006, which imposes stiff criminal penalties on anyone who uses pretexting to obtain confidential information.

So how does one go about assessing security awareness programs aimed at countering social engineering in all its forms? One way is to keep track of the number of times users fall victim to these attacks before and after the awareness training effort. The challenge with this approach is that victims may not spontaneously confess to falling for

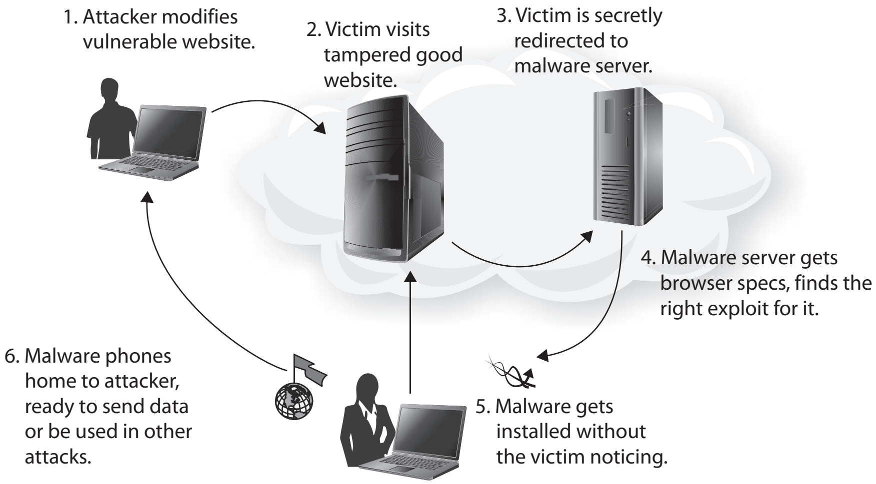


Figure 19-3 Drive-by downloads

these tricks, and our security systems will certainly not detect all instances of successful attacks. Another approach is to have auditors (internal or external) conduct benign social engineering campaigns against our users. When users click a link inserted by the auditors, they are warned that they did something wrong and perhaps are redirected to a web page or short video explaining how to avoid such mistakes in the future. All the while, our automated systems are keeping tabs on which users are most susceptible and how often these attacks are successful. Anecdotal evidence suggests that there is a group of users who will not respond to remedial training, so the leadership should decide what to do with individuals who repeatedly make the wrong choices.

Online Safety

Oftentimes users don't have to be tricked into doing something wrong, but willingly go down that path. This is often the result of ignorance of the risks, and the remediation of this ignorance is the whole point of the security awareness campaign. An effective security awareness program should include issues associated with unsafe online behavior that could represent risk for the organization.

Perhaps one of the most important elements of safe online behavior is the proper use of social media. A good starting point is the proper use of privacy settings, particularly considering that all major social media sites have means to restrict what information is shared with whom. The default settings are not always privacy-focused, so it is important for users to be aware of their options. This becomes particularly important when users post information concerning their workplace. Part of the security awareness program should be to educate users about the risks they can pose to their employers if their posts reveal sensitive information. Once posted, the information cannot be recalled; it is forevermore out there.

Sometimes it is not what goes out to the Internet but what comes in from it that should concern users. Simply surfing to the wrong website, particularly from a workplace computer, may be all it takes to bring down the whole organization. In the case of a drive-by download, the attack is triggered simply by visiting a malicious website. While the mechanisms vary, the effect can be the execution of malware on the client computer, with or without additional user interaction. While web filters can mitigate some of the risk of surfing to inappropriate sites, malicious websites sometimes are legitimate ones that have been compromised, which means that the filters may not be effective.

While some downloads happen without user knowledge or interaction, others are intentional. It is not unusual for naïve users to attempt to download and install unauthorized and potentially risky applications on their computers. Unfortunately, many organizations do not use software whitelisting and even allow their users to have administrative privileges on their computers, which allows them to install any application they desire. Even benign applications can be problematic for the security of our systems, but when you consider that the software may come from an untrusted and potentially malicious source, the problem is compounded.

Assessing the effectiveness of an awareness campaign that promotes users' online safety is not easy and typically requires a multipronged approach. Social media posts may be detected using something as simple as Google Alerts, which trigger whenever Google's robots find a term of interest online. A simple script can then filter out the alerts by source in order to separate, say, a news outlet report on our organization from an ill-advised social media post. The software download problem (whether intentional or not) can be assessed by a well-tuned IDS. Over time, with an effective awareness campaign, we should see the number of incidents go down, which will allow us to focus our attention on repeat offenders.

Data Protection

We already covered data protection in Chapter 6, but for the purposes of assessing a security awareness program, it bears repeating that sensitive data must always be encrypted whether at rest or in transit. It is possible for users to circumvent controls and leave this data unprotected, so awareness is a key to preventing this type of behavior. Unencrypted data is vulnerable to leaks if it is stored in unauthorized online resources or intentionally (but perhaps not maliciously) shared with others. Another important topic is the proper destruction of sensitive data when it is no longer needed and falls out of the mandatory retention period (see Chapter 5).

Testing the degree to which our users are aware of data protection requirements and best practices can best be done by using tags in our files' metadata. The information classification labels we discussed in Chapter 5 become an effective means of tracking where our data is. Similarly, data loss prevention (DLP) solutions can help stop leaks and identify individuals who are maliciously or inadvertently exposing our sensitive information. This allows us to target those users either with additional awareness training or with disciplinary actions.

Culture

At the end of the day, the best way to test the security awareness of an organization may be by assessing its security culture. Do we have the kind of environment in which users feel safe self-reporting? Are they well incentivized to do so? Do they actively seek information and guidance when encountering a strange or suspicious situation? Self-reports and requests for information by users provide a good indicator of whether the organizational culture is helping or hindering us in securing our systems.

Disaster Recovery and Business Continuity

Most organizations cannot afford to be incapable of performing their business processes for very long. Depending on the specific organization, the acceptable downtime can be measured in minutes, hours, or, in some noncritical sectors, maybe days. Consequently, we all need to have procedures in place for ensuring we can go on working regardless of what happens around or to us. As introduced in Chapter 2, *business continuity* is the term used to describe the processes enacted by an organization to ensure that its vital business processes remain unaffected or can be quickly restored following a serious incident. Business continuity looks holistically at the entire organization. A subset of this effort, called *disaster recovery*, focuses on restoring the information systems after a disastrous event. Like any other business process, these processes must be periodically assessed to ensure they are still effective.

Often, the initial response to an emergency affects the ultimate outcome. Emergency response procedures are the prepared actions that are developed to help people in a crisis situation better cope with the disruption. These procedures are the first line of defense when dealing with a crisis situation. People who are up to date on their knowledge of these procedures will perform the best, which is why training and drills are very important. Emergencies are unpredictable, and no one knows when they will be called upon to perform their disaster recovery duties.

Protection of life is of the utmost importance and should be dealt with first before attempting to save material objects. Emergency procedures should show the people in charge how to evacuate personnel safely (see Table 19-1). All personnel should know their designated emergency exits and destinations. Emergency gathering spots should take into consideration the effects of seasonal weather. One person in each designated group is often responsible for making sure all people are accounted for. One person in particular should be responsible for notifying the appropriate authorities: the police department, security guards, fire department, emergency rescue, and management. With proper training, employees will be better equipped to handle emergencies and avoid the reflex to just run to the exit.

EXAM TIP Protection of human life is always the top priority in situations where it is threatened.

If the situation is not life threatening, designated staff should shut down systems in an orderly fashion, and remove critical data files or resources during evacuation for safekeeping. There is a reason for the order of activities. As with all processes, there are

Procedure: Personnel Evacuation Description	Location	Names of Staff Trained to Carry Out Procedure	Date Last Carried Out
Each floor within the building must have two individuals who will ensure that all personnel have been evacuated from the building after a disaster. These individuals are responsible for performing employee head count, communicating with the business continuity plan (BCP) coordinator, and assessing emergency response needs for their employees.	West wing parking lot	David Miller Michelle Lester	Drills were carried out on May 4, 2021.
Comments: These individuals are responsible for maintaining an up-to-date listing of employees on their specific floor. These individuals must have a company-issued walkie-talkie and proper training for this function.			

Table 19-1 Sample Emergency Response Procedure

dependencies with everything we do. Deciding to skip steps or add steps could in fact cause more harm than good.

Once things have approached a reasonable plateau of activity, one or more people will most likely be required to interface with external entities, such as the press, customers, shareholders, and civic officials. One or more people should be prepped in their reaction and response to the recent disaster so a uniform and reasonable response is given to explain the circumstances, how the organization is dealing with the disaster, and what customers and others should now expect from the organization. The organization should quickly present this information instead of allowing others to come to their own conclusions and start false rumors. At least one person should be available to the press to ensure proper messages are being reported and sent out.

Another unfortunate issue needs to be addressed prior to an emergency: potential looting, vandalism, and fraud opportunities from both a physical perspective and a logical perspective. After an organization is hit with a large disturbance or disaster, it is usually at its most vulnerable, and others may take advantage of this vulnerability. Careful thought and planning, such as provision of sufficient security personnel on site, enable the organization to deal with these issues properly and provide the necessary and expected level of protection at all times.

Ideally, we collect most of the data we need for assessing our disaster recovery and business continuity processes before any real emergencies arise. This allows us to ensure we are prepared and to improve the effectiveness of our organizational responses to these unforeseen events. Still, the best data is captured during an actual emergency situation. After any real or training events, it is imperative that we have a debriefing immediately after it. This event, sometimes called a *hot wash*, must happen while memories are still fresh. It is an ad hoc discussion of what happened, how we dealt with it, what went well, and how we can do better in the future. Ideally, it is followed by a more deliberate *after-action review (AAR)* that takes place later, once the stakeholders have had a chance to think through the events and responses and analyze them in more detail. Hot wash notes and AAR reports are excellent sources of security process data for disaster recovery and business continuity.

Reporting

For many security professionals, report writing is perhaps one of the least favorite activities, and yet it is often one of the most critical tasks for our organizations. While we all thrive on putting hands on keyboards and patch panels when it comes to securing our networks, we often cringe at the thought of putting in writing what it is that we've done and what it means to the organization. This is probably the task that best distinguishes the true security professional from the security practitioner: the professional understands the role of information systems security within the broader context of the business and is able to communicate this to both technical and nontechnical audiences alike.

It seems that many of us have no difficulty (though perhaps a bit of reluctance) describing the technical details of a plan we are proposing, a control we have implemented, or an audit we have conducted. It may be a bit tedious, but we've all done this at some point in our careers. The problem with these technical reports, important though they are, is that they are written by and for technical personnel. If your CEO is a technical person running a technical company, this may work fine. However, sooner or later most of us will work with decision-makers that are not inherently technical. These leaders will probably not be as excited about the details of an obscure vulnerability you just discovered as they will be about its impact on the business. If you want your report to have a business impact, it must be both technically sound and written in the language of the business.

Analyzing Results

Before you start typing that report, however, you probably want to take some time to review the outputs, ensure you understand them, and then infer what they mean to your organization. Only after analyzing the results can you provide insights and recommendations that will help maintain or improve your organization's security.

The goal of this analysis process is to move logically from facts to actionable information. A list of vulnerabilities and policy violations is of little value to business leaders unless it is placed in context. Once you have analyzed all the results in this manner, you'll be ready to start writing the official report.

You can think of analyzing results as a three-step process to determine the following: What?, So what?, and Now what? First you gather all your data, organize it, and study it carefully. You find out *what* is going on. This is where you establish the relevant and interesting facts. For example, you may have determined the fact that 12 of your servers are not running on the latest software release. Worse yet, you may have found that three of those servers have vulnerabilities that are being exploited in the wild. The instinctive reaction of many would be to say this is a big deal that needs to be corrected immediately. But wait.

The second step in your analysis is to determine the business impact of those facts. This is the *so what*? Though we tend to focus on the technology and security aspects of our environments, we have a responsibility to consider facts in a broader organizational context. Continuing with the previous example, you may find that those 12 servers provide a critical business function and cannot be updated in the near term for perfectly legitimate operations reasons. You may also discover that you already have compensatory administrative or technical controls that mitigate the risk they pose. So maybe it's not that big of a deal after all.

The third step is to figure out the *now what*? The whole point of measuring security is to ensure it is sufficient or to improve it so that it is sufficient. The analysis process leads to results, and these are only valuable if they are actionable. They must point to one or more sound recommendations that address the broader organizational needs. In our example, you clearly don't want to leave those servers as they are indefinitely. Maybe you have considered two courses of action: either leave things as they are but reassess every 30 days or update the servers immediately despite the resulting business impact. You evaluate the alternatives using risk and business impact as decision criteria and ultimately decide that keeping an extra-close eye on the unpatched servers for a few more weeks is the better course of action. You put down a date for the next decision point and go from there. The point is that your decision is based on a sound analysis of the facts.

Remediation

Most assessments uncover vulnerabilities. While many cybersecurity practitioners think of vulnerabilities in terms of software defects to be patched, the reality is that most vulnerabilities in the average organization tend to come from misconfigured systems, inadequate policies, unsound business processes, or unaware staff. Correcting most of these vulnerabilities requires engagement by more than just the IT or security teams. Even the more mundane system patches need to be carefully coordinated with all affected departments within the organization. Vulnerability remediation should include all stakeholders, especially those who don't have the word "security" anywhere in their job titles.

The fact that you're leveraging a multifunctional extended team to remediate vulnerabilities highlights the need for the sound analyses described in the previous section. You'll need the support of everyone from the very top of the organization on down, which is why you want to educate them on your findings, why they are impacted, and what you must all do about them. It is likely that remediation will impact the business, so it is also critical to have contingency plans and be able to handle exceptional cases.

Exception Handling

Sometimes, vulnerabilities simply can't be patched (at least, not in any reasonable amount of time). Some of us have dealt with very big and expensive medical devices that require Food and Drug Administration accreditations that preclude their patching without putting them through an expensive and time-consuming recertification process. The solution is to implement compensatory controls around the problem, document the exception, and revisit the vulnerability over time to see if can be remediated directly at some point in the future. For example, a medical device may be micro-segmented in its own VLAN behind a firewall that would only allow one other device to communicate with it, and then using only a specific port and protocol.

The Language of Your Audience

You cannot be an effective communicator if you don't know your audience. Learning to speak the language(s) of those you are trying to inform, advise, or lead is absolutely critical. It has been said that accounting is the language of business, which means you can generally do well communicating in terms of the financial impacts of your findings. The fact that risks are expressed as the probability of a certain amount of loss should make this fairly easy as long as you have some sort of risk management program in place.

Still, in order to up your game, you want to be able to communicate in the language of the various disciplines that make up a business. Human resource leaders will care most about issues like staff turnover and organizational culture. Your marketing (or public affairs) team will be focused on what external parties think about your organization. Product managers will be very reluctant to support proposals that can slow down their delivery tempo. We could go on, but the point is that, while the facts and analyses must be unassailable, you should always try to communicate them in the language of…whoever it is you're trying to persuade.

Ethical Disclosure

Occasionally, security assessments lead to discoveries of vulnerabilities that were not known and which affect other organizations. Perhaps you were performing a code review on one of the products your company sells and you discovered a vulnerability, or maybe your pentesting team was conducting a pen test on a system your organization bought from one of its vendors and they found a previously unknown way to exploit the system. However you discover the vulnerability, you have an ethical obligation to properly disclose it to the appropriate parties. If the vulnerability is in your own product, you need to notify your customers and partners as soon as possible. If it is in someone else's product, you need to notify the vendor or manufacturer immediately so they can fix it. The goal of ethical disclosure is to inform anyone who might be affected as soon as feasible, so a patch can be developed before any threat actors become aware of the vulnerability.

More commonly, exception handling is required because something crashed while we were attempting to patch a system. Though we should always test patches in a sandbox environment before pushing them out to production systems, we can never be 100 percent certain that something won't go wrong. In those cases, particularly if the system is mission-critical, we roll back the patch, get the system back online as quickly and securely as we can, document the exception, and move on with remediation of other systems. We circle back, of course, but exception handling is typically a time-intensive effort that should not delay the larger remediation effort.

Writing Technical Reports

After analyzing the assessment results, the next step is to document. A technical report should be much more than the output of an automated scanning tool or a generic checklist with yes and no boxes. There are way too many so-called auditors that simply push the start button on a scanning tool, wait for it to do its job, and then print a report with absolutely none of the analysis we just discussed.

A good technical report tells a story that is interesting and compelling *for its intended audience*. It is very difficult to write one without a fair amount of knowledge about its readers, at least the most influential ones. Your goal, after all, is to persuade them to take whatever actions are needed to balance risks and business functions for the betterment of the organization. Simultaneously, you want to anticipate likely objections that could undermine the conversation. Above all else, you must be absolutely truthful and draw all conclusions directly from empirical facts. To improve your credibility, you should always provide in an appendix the relevant raw data, technical details, and automated reports.

The following are key elements of a good technical audit report:

- **Executive Summary** We'll get into the weeds of this in the next section, but you should always consider that some readers may not be able to devote more than a few minutes to your report. Preface it with a hard-hitting summary of key take-aways.

- **Background** Explain why you conducted the experiment/test/assessment/audit in the first place. Describe the scope of the event, which should be tied to the reason for doing it in the first place. This is a good place to list any relevant references such as policies, industry standards, regulations, or statutes.
- **Methodology** As most of us learned in our science classes, experiments (and audits) must be repeatable. Describe the process by which you conducted the study. This is also a good section in which to list the personnel who participated, dates, times, locations, and any parts of the system that were excluded (and why).
- **Findings** You should group your findings to make them easier to search and read for your audience. If the readers are mostly senior managers, you may want to group your findings by business impact. Technologists may prefer groupings by class of system. Each finding should include the answer to "so what?" from your analysis.
- **Recommendations** This section should mirror the organization of your findings and provide the "now what?" from your analysis. This is the actionable part of the report, so you should make it compelling. When writing it, you should consider how each key reader will react to your recommendations. For instance, if you know the CFO is reluctant to make new capital investments, then you could frame expensive recommendations in terms of operational costs instead.
- **Appendices** You should include as much raw data as possible, but you certainly want to include enough to justify your recommendations. Pay attention to how you organize the appendices so that readers can easily find whatever data they may be looking for.

If you are on the receiving end of this process, always be wary of reports that look auto-generated, which usually points to an ineffective auditing team. Also be careful about reports that, having failed to find any significant vulnerabilities, overemphasize the importance of less important flaws. If the security posture of the organization is good, then the auditors should not shy away from saying so.

Executive Summaries

Getting into the technical weeds with an audit report is wonderful for techies, but it doesn't do the business folks any good. The next step in writing impactful reports is to translate the key findings and recommendations into language that is approachable and meaningful to the senior leadership of your organization. After all, it is their support that will allow you to implement the necessary changes. They will provide both the authority and resources that you will need.

Typically, technical reports (among others) include an executive summary of no more than a page or two, which highlights what senior leaders need to know from the report. The goal is to get their attention and effect the desired change. One way to get a business leader's attention is to explain the audit findings in terms of risk exposure. Security is almost always perceived as a cost center for the business. A good way to show return on investment (ROI) for a department that doesn't generate profits is by quantifying how much money a recommended change could potentially save the company.

One way to quantify risk is to express it in monetary terms. We could say that the risk (in dollars) is the value of an asset multiplied by the probability of the loss of that asset. In other words, if our customer's data is worth $1 million and there is a 10 percent chance that this data will be breached, then our risk for this data breach would be $100,000. How can we come up with these values? There are different ways in which accountants valuate other assets, but the most common are the following.

- The *cost approach* simply looks at the cost of acquiring or replacing the asset. This is the approach we oftentimes take to valuating our IT assets (minus information, of course). How might it be applied to information? Well, if an information asset is a file containing a threat intelligence report that cost the organization $10,000, then the cost approach would attach that value to this asset.
- The *income approach* considers the expected contribution of the asset to the firm's revenue stream. The general formula is value equals expected (or potential) income divided by capitalization rate. The capitalization rate is the actual net income divided by the value of the asset. So, for instance, if that $10,000 threat intelligence report brought in $1,000 in net income last year (so the capitalization rate is 0.10) and our projections are that it will bring in $2,000 this year, then its present value would be $2,000 ÷ 0.10, or $20,000. As you should be able to see, the advantage of this approach is that it takes into account the past and expected business conditions.
- The *market approach* is based on determining how much other firms are paying for a similar asset in the marketplace. It requires a fair amount of transparency in terms of what other organizations are doing. For instance, if we have no way of knowing how much others paid for that threat intelligence report, then we couldn't use a market approach to valuating it. If, on the other hand, we were able to find out that the going rate for the report is actually $12,000, then we can use that value for our report (asset) and celebrate that we got a really good deal.

So, as long as the life-cycle costs of implementing our proposed controls (say, $180,000) are less than the risks they mitigate (say, $1,000,000), it should be obvious that we should implement the control, right? Not quite. The controls, after all, are not perfect. They will not be able to eliminate the risk altogether, and will sometimes fail. This means that we need to know the likelihood that the control will be effective at thwarting an attack. Let's say that we are considering a solution that has been shown to be effective about 80 percent of the time and costs $180,000. We know that we have a 10 percent chance of being attacked and, if we are, that we have a 20 percent chance of our control failing to protect us. This means that the residual risk is 2 percent of $1,000,000, or $20,000. This is then added to the cost of our control ($180,000) to give us the total effective cost of $200,000.

This is the sort of content that is impactful when dealing with senior leaders. They want to know the answers to questions such as these: How likely is this control to work? How much will it save us? How much will it cost? The technical details are directly important to the ISMS team and only indirectly important to the business leaders. Keep that in mind the next time you package an audit report for executive-level consumption.

Management Review and Approval

A management review is a formal meeting of senior organizational leaders to determine whether the management systems are effectively accomplishing their goals. In the context of the CISSP, we are particularly interested in the performance of the ISMS. While we restrict our discussion here to the ISMS, you should be aware that the management review is typically much broader in scope.

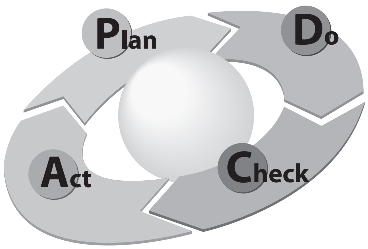
While management reviews have been around for a very long time, the modern use of the term is perhaps best grounded in quality standards such as the ISO 9000 series. These standards define a Plan-Do-Check-Act loop, depicted in Figure 19-4. This cycle of continuous improvement elegantly captures the essence of most topics we cover in this book. The Plan phase is the foundation of everything else we do in an ISMS, because it determines our goals and drives our policies. The Do phase of the loop is the focal point of Part VII of this book ("Security Operations"). The Check phase is the main topic of this chapter and the previous one. Lastly, the Act phase is what we formally do in the management review. We take all the information derived from the preceding stages and decide whether we need to adjust our goals, standards, or policies in order to continuously improve our posture.

The management review, unsurprisingly, looks at the big picture in order to help set the strategy moving forward. For this reason, a well-run review will not be drawn into detailed discussions on very specific technical topics. Instead, it takes a holistic view of the organization and makes strategic decisions, which is the primary reason why the management review must include all the key decision makers in the organization. This top-level involvement is what gives our ISMS legitimacy and power.

When communicating with senior executives, it is important to speak the language of the business and to do so in a succinct manner. We already discussed this style of communication when we covered reports in the previous section, but it bears repeating here. If we are not able to clearly and quickly get the point across to senior leaders on the first try, we may not get another chance to do so.

PART VI

Figure 19-4 The Plan-Do-Check-Act loop



Before the Management Review

The management review should happen periodically. The more immature the management system and/or the organization, the more frequent these reviews should take place. Obviously, the availability of the key leaders will be a limiting factor during scheduling. This periodicity helps ensure that the entire organization is able to develop an operational rhythm that feeds the senior-level decision-making process. Absent this regularity, the reviews risk becoming reactive rather than proactive.

The frequency of the meetings should also be synchronized with the length of time required to implement the decisions of the preceding review. If, for instance, the leaders decided to implement sweeping changes that will take a year to develop, integrate, and measure, then having a review before the year is up may not be particularly effective. This is not to say that enough time must lapse to allow every single change to yield measurable results, but if these reviews are conducted too frequently, management won't be able to make decisions that are informed by the results of the previous set of actions.

Reviewing Inputs

The inputs to the management review come from a variety of sources. A key input is the results of relevant audits, both external and internal. These are, in part, the reports described earlier in the chapter. In addition to making the audit reports available for review, it is also necessary to produce executive summaries that describe the key findings, the impact to the organization, and the recommended changes (if any). Remember to write these summaries in business language.

Another important input to the review is the list of open issues and action items from the previous management review. Ideally, all these issues have been addressed and all actions have been completed and verified. If that is not the case, it is important to highlight whatever issues (e.g., resources, regulations, changes in the landscape) prevented them from being closed. Senior leaders normally don't like surprises (particularly unpleasant ones), so it might be wise to warn them of any unfinished business before the review is formally convened.

In addition to the feedback from auditors and action officers, customer feedback is an important input to the management review. Virtually every organization has customers, and they are normally the reason for the organization to exist in the first place. Their satisfaction, or lack thereof, is crucial to the organization's success. Chapter 18 mentioned real user monitoring (RUM) as one way of measuring their interactions with our information systems. Organizations are also increasingly relying on social media analysis to measure customer sentiments with regard to the organization in general and specific issues. Finally, we can use questionnaires or surveys, although these tend to have a number of challenges, including very low response rates and negative bias among respondents.

The final inputs to the management review are the recommendations for improvement based on all the other inputs. This is really the crux of the review. (While it is technically possible for a review to include no substantive change recommendations, it would be extremely unusual since it would mean that the ISMS team cannot think of any way to improve the organizational posture.) The ISMS team presents proposed high-level changes that require the approval and/or support of the senior leaders. This is not the place to discuss low-level tactical changes; we can take care of those ourselves. Instead, we would want to ask for changes to key policies or additional resources. These recommendations must logically follow from the other inputs that have been presented to the review panel.

In setting the stage for the senior leaders' decision-making process, it is often useful to present them with a range of options. Many security professionals typically offer three to five choices, depending on the complexity of the issues. For instance, one option could be "do nothing," which describes what happens if no changes are made. At the other end of the spectrum, we could state an option that amounts to the solid-gold approach in which we pull out all the stops and make bold and perhaps costly changes that are all but guaranteed to take care of the problems. In between, we would offer one to three other choices with various levels of risk, resource requirements, and business appeal.

When we present the options, we should also present objective evaluative criteria for management to consider. A criterion that is almost always required in the presentation is the monetary cost of the change. This factor should be the life-cycle cost of the option, not just the cost of implementation. It is a common mistake to overlook the maintenance costs over the life of the system/process, disregarding the fact that these costs are often much greater than the acquisition price tag. Other factors you may want to consider presenting are risk, impact on existing systems or processes, training requirements, and complexity. But whatever evaluative factors you choose, you should apply them to each of the options in order to assess which is the best one.

Management Approval

The senior leadership considers all the inputs; typically asks some pretty pointed questions; and then decides to approve, reject, or defer the recommendations. The amount of debate or discussion at this point is typically an indicator of how effective the ISMS team was at presenting sound arguments for changes that are well nested within (and supportive of) the business processes. Obviously, the leadership's decisions are the ultimate testament to how convincing the ISMS team's arguments were.

Typically, senior management will decide to either approve the recommendation in its entirety, approve it with specific changes, reject the recommendation, or send the ISMS team back to either get more supporting data or redesign the options. Regardless of the outcome, there will likely be a list of deliverables for the next management review that will have to be addressed. It is a good idea to conclude the management review with a review of open and action items, who will address them, and when each is due. These all become inputs to the next management review in a cycle that continues indefinitely.

Chapter Review

Whereas the focus of Chapter 18 was assessing and testing technical controls, this chapter discussed administrative controls, analyzing results, and communicating them effectively. We also introduced a couple of tools that will make this effort a whole lot easier (and more effective) for you: security metrics, KPIs, and KRIs. Together with the topics discussed in the previous chapter, we hope to have given you useful insights into how to measure and improve your ISMS, particularly when improvements depend on your ability to persuade other leaders in your organization to support your efforts. This all sets the stage for the next part of this book: "Security Operations."

Quick Review

- A factor is an attribute of an ISMS that has a value that can change over time.
- A measurement is a quantitative observation of a factor at a particular point in time.
- A baseline is a value for a factor that provides a point of reference or denotes that some condition is met by achieving some threshold value.
- A metric is a derived value that is generated by comparing multiple measurements against each other or against a baseline.
- Good metrics are relevant, quantifiable, actionable, robust, simple, and comparative.
- An indicator is a particularly important metric that describes a key element of the effectiveness of an ISMS.
- A key performance indicator (KPI) is an indicator that is particularly significant in showing the performance of an ISMS compared to its stated goals.
- Key risk indicators (KRIs) measure the risk inherent in performing a given action or set of actions.
- Privileged user accounts pose significant risk to the organization and should be carefully managed and controlled.
- User accounts should be promptly suspended whenever the user departs the organization permanently or for an extended period.
- Data backups should not be considered reliable unless they have been verified to be usable to restore data.
- Business continuity is the term used to describe the processes enacted by an organization to ensure that its vital business processes remain unaffected or can be quickly restored following a serious incident.
- Disaster recovery focuses on restoring the information systems after a disastrous event and is a subset of business continuity.
- Security training is the process of teaching a skill or set of skills that enables people to perform specific functions better.
- Security awareness training is the process of exposing people to security issues so that they are able to recognize and respond to them better.
- Social engineering, in the context of information security, is the process of manipulating individuals so that they perform actions that violate security protocols.
- Phishing is social engineering conducted through a digital communication.

- A drive-by download is an automatic attack that is triggered simply by visiting a malicious website.
- Disaster recovery and business continuity processes both need to be evaluated regularly to ensure they remain effective in the face of environmental changes in and around the organization.
- Reports must be written with a specific audience in mind if they are to be effective.
- A management review is a formal meeting in which senior organizational leaders determine whether the information security management systems are effectively accomplishing their goals.

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. What is a key performance indicator (KPI)?

A. A value for a factor that denotes that some condition is met

B. The result of comparing multiple measurements

C. A significant indicator that shows the performance of an ISMS

D. A quantitative observation of a factor of an ISMS at a point in time

2. Which of the following is true about key risk indicators (KRIs)?

A. They tell managers where an organization stands with regard to its goals.

B. They are inputs to the calculation of single loss expectancy (SLE).

C. They tell managers where an organization stands with regard to its risk appetite.

D. They represent an interpretation of one or more metrics that describes the effectiveness of the ISMS.

3. All of the following are normally legitimate reasons to suspend rather than delete user accounts *except*

A. Regulatory compliance

B. Protection of the user's privacy

C. Investigation of a subsequently discovered event

D. Data retention policy

4. Data backup verification efforts should

A. Have the smallest scope possible

B. Be based on the threats to the organization

C. Maximize impact on business

D. Focus on user data

5. What is the difference between security training and security awareness training?

A. Security training is focused on skills, while security awareness training is focused on recognizing and responding to issues.

B. Security training must be performed, while security awareness training is an aspirational goal.

C. Security awareness training is focused on security personnel, while security training is geared toward all users.

D. There is no difference. These terms refer to the same process.

6. Which of the following is *not* a form of social engineering?

A. Pretexting

B. Fishing

C. Whaling

D. Blackmailing

7. When assessing the performance of your organization during a disaster recovery drill, which is the highest priority?

A. Safeguarding sensitive assets

B. Notifying the appropriate authorities

C. Preventing looting and vandalism

D. Protection of life

8. Which of the following is true about vulnerability remediation after an organizational security assessment?

A. All vulnerabilities uncovered must be remediated as soon as possible.

B. It entails applying patches to all vulnerable software systems.

C. Properly done, it should never impact the business.

D. It requires the support of everyone from the very top of the organization.

9. Which of the following is true of management reviews?

A. They happen periodically and include results of audits as a key input.

B. They happen in an ad hoc manner as the needs of the organization dictate.

C. They are normally conducted by mid-level managers, but their reports are presented to the key business leaders.

D. They are focused on assessing the management of the information systems.

Answers

1. **C.** Key performance indicators (KPIs) are indicators that are particularly significant in showing the performance of an ISMS compared to its stated goals. Because every KPI is a metric, answer B (the partial definition of a metric) would also be correct but would not be the best answer since it leaves out the significance and purpose of the metric.
2. **C.** Key risk indicators (KRIs) allow managers to understand when specific activities of the organization are moving it toward a higher level of risk. They are useful to understanding changes and managing the overall risk.
3. **B.** If the organization was intentionally attempting to protect the privacy of its user, suspension of the account would be a poor privacy measure compared to outright deletion.
4. **B.** The verification of data backups should focus on assessing the organization's ability to respond to the threats identified during the threat modeling and risk management processes. If the organization can't respond to these threats, then its backups may be useless.
5. **A.** Security training is the process of teaching a skill or set of skills that will enable people to perform specific functions better. Security awareness training, on the other hand, is the process of exposing people to security issues so that they are able to recognize and respond to them better. Security training is typically provided to security personnel, while security awareness training should be provided to every member of the organization.
6. **B.** The correct term for social engineering conducted over digital communications means is phishing, not fishing.
7. **D.** In any situation where loss or harm to human lives is a possible outcome, protection of life is the top priority. The other options are all part of a disaster recovery process, but are never the top priority.
8. **D.** Because most remediations will have some impact on the business, they require the support of everyone. This is particularly true of organizational (as opposed to system-specific) assessments because not all vulnerabilities will involve just a software patch.
9. **A.** Management reviews work best when they are regularly scheduled events involving the key organizational leaders, because this allows the subordinate leaders to plan and conduct the assessments, such as audits that provide inputs to the review.

PART VII

Security Operations

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CHAPTER 20

Managing Security Operations

This chapter presents the following:

- Foundational security operations concepts
- Change management processes
- Configuration management
- Resource protection
- Patch and vulnerability management
- Physical security management
- Personnel safety and security

Management is keeping the trains running on time.

—Andy Dunn

Security operations is a broad field, but the image that comes to many of our minds when we hear the term is a security operations center (SOC) where analysts, threat hunters, and incident responders fight off cyberthreats day in and day out. That is, in fact, an important aspect of security operations, but it isn't the complete scope. A lot of other work goes into ensuring our spaces are protected, our systems are optimized, and our people are doing the right things. This chapter covers many of the issues that we, as security leaders, must tackle to create a secure operational environment for our organizations. Security operations is the business of managing security. It may not be as exciting as hunting down a threat actor in real time, but it is just as important.

Foundational Security Operations Concepts

Security operations revolves around people much more than around computers and networks. A good chunk of our jobs as CISSPs is to lead security teams who prevent teams of attackers from causing us harm; our computers and networks are just the battlefields on which these groups fight each other. Sometimes, it is our own teammates who can become the enemy, either deliberately or through carelessness. So, we can't really manage security operations without first understanding the roles we need our teammates to fill and the ways in which we keep the people filling those roles honest.

Table 20-1 shows some of the common IT and security roles within organizations and their corresponding job definitions. Each role needs to have a completed and well-defined job description. Security personnel should use these job descriptions when assigning access rights and permissions in order to ensure that individuals have access only to those resources needed to carry out their tasks.

Table 20-1 contains just a few roles with a few tasks per role. Organizations should create a *complete* list of roles used within their environment, with each role's associated tasks and responsibilities. This should then be used by data owners and security personnel when determining who should have access to specific resources and the type of access. A clear and unambiguous understanding of roles and responsibilities across the organization is critical to managing security. Without it, ensuring that everyone has the right access they need for their jobs, and no more, becomes very difficult. In the sections that follow we look at other foundational concepts we all need to be able to apply to our security operations.

Organizational Role	Core Responsibilities
Cybersecurity Analyst	Monitors the organization's IT infrastructure and identifies and evaluates threats that could result in security incidents
Help Desk/Support	Resolves end-user and system technical or operations problems
Incident Responder	Investigates, analyzes, and responds to cyber incidents within the organization
IT Engineer	Performs the day-to-day operational duties on systems and applications
Network Administrator	Installs and maintains the local area network/wide area network (LAN/WAN) environment
Security Architect	Assesses security controls and recommends and implements enhancements
Security Director	Develops and enforces security policies and processes to maintain the security and safety of all organizational assets
Security Manager	Implements security policies and monitors security operations
Software Developer	Develops and maintains production software
System Administrator	Installs and maintains specific systems (e.g., database, e-mail)
Threat Hunter	Proactively finds cybersecurity threats and mitigates them before they compromise the organization

Table 20-1 Roles and Associated Tasks

SecOps

In many organizations the security and IT operations teams become misaligned because their responsibilities have different (and oftentimes conflicting) focuses. The operations staff is responsible for ensuring systems are operational, highly available, performing well, and providing users with the functionality they need. As new technology becomes available, they come under pressure by business leaders to deploy it as soon as possible to improve the organization's competitiveness. But many times this focus on operations and user functionality comes at the cost of security. Security mechanisms commonly decrease performance, delay provisioning, and reduce the functionality available to the users.

The conflicts between the priorities and incentives of the IT operations and security teams can become dysfunctional in many organizations. Many of us have witnessed the finger pointing and even outright hostility that can crop up when things go wrong. A solution that is catching on is *SecOps* (Security + Operations), which is the integration of security and IT operations people, technology, and processes to reduce risks while improving business agility. The goal is to create a culture in which security is baked into the entire life cycle of every system and process in the organization. This is accomplished by building multifunctional teams where, for instance, a cloud system administrator and a cloud security engineer work together under the leadership of a manager who is responsible for delivering agile *and* secure functionality to the organization.

Accountability

Users' access to resources must be limited and properly controlled to ensure that excessive privileges do not provide the opportunity to cause damage to an organization and its resources. Users' access attempts and activities while using a resource need to be properly monitored, audited, and logged. The individual user ID needs to be included in the audit logs to enforce individual responsibility. Each user should understand his responsibility when using organizational resources and be accountable for his actions.

Capturing and monitoring audit logs helps determine if a violation has actually occurred or if system and software reconfiguration is needed to better capture only the activities that fall outside of established boundaries. If user activities were not captured and reviewed, it would be very hard to determine if users have excessive privileges or if there has been unauthorized access.

Auditing needs to take place in a routine manner. Also, security analysts and managers need to review audit and log events. If no one routinely looks at the output, there really is no reason to create logs. Audit and function logs often contain too much cryptic or mundane information to be interpreted manually. This is why products and services are available that parse logs for organizations and report important findings. Logs should be monitored and reviewed, through either manual or automatic methods, to uncover suspicious activity and to identify an environment that is shifting away from its original baselines. This is how administrators can be warned of many problems before they become too big and out of control.

When reviewing events, administrators need to ask certain questions that pertain to the users, their actions, and the current level of security and access:

- *Are users accessing information and performing tasks that are not necessary for their job description?* The answer indicates whether users' rights and permissions need to be reevaluated and possibly modified.
- *Are repetitive mistakes being made?* The answer indicates whether users need to have further training.
- *Do too many users have rights and privileges to sensitive or restricted data or resources?* The answer indicates whether access rights to the data and resources need to be reevaluated, whether the number of individuals accessing them needs to be reduced, and/or whether the extent of their access rights should be modified.

Need-to-Know/Least Privilege

Least privilege (one of the secure design principles introduced in Chapter 9) means an individual should have just enough permissions and rights to fulfill her role in the organization and no more. If an individual has excessive permissions and rights, it could open the door to abuse of access and put the organization at more risk than is necessary. For example, if Dusty is a technical writer for a company, he does not necessarily need to have access to the company's source code. So, the mechanisms that control Dusty's access to resources should not let him access source code.

Another way to protect resources is enforcing *need to know*, which means we must first establish that an individual has a legitimate, job role–related need for a given resource. Least privilege and need to know have a symbiotic relationship. Each user should have a need to know about the resources that she is allowed to access. If Mikela does not have a need to know how much the company paid last year in taxes, then her system rights should not include access to these files, which would be an example of exercising least privilege. The use of identity management software that combines traditional directories; access control systems; and user provisioning within servers, applications, and systems is becoming the norm within organizations. This software provides the capabilities to ensure that only specific access privileges are granted to specific users, and it often includes advanced audit functions that can be used to verify compliance with legal and regulatory directives.

Separation of Duties and Responsibilities

The objective of separation of duties (another of the secure design principles introduced in Chapter 9) is to ensure that one person acting alone cannot compromise the organization's security in any way. High-risk activities should be broken up into different parts and distributed to different individuals or departments. That way, the organization does not need to put a dangerously high level of trust in certain individuals. For fraud to take place, collusion would need to be committed, meaning more than one person would have to be involved in the fraudulent activity. Separation of duties, therefore, is a preventive measure that requires collusion to occur for someone to commit an act that is against policy.

Separation of duties helps prevent mistakes and minimize conflicts of interest that can take place if one person is performing a task from beginning to end. For instance, a programmer should not be the only one to test her own code. Another person with a different job and agenda should perform functionality and integrity testing on the programmer's code, because the programmer may have a focused view of what the program is supposed to accomplish and thus may test only certain functions and input values, and only in certain environments.

Another example of separation of duties is the difference between the functions of a computer user and the functions of a security administrator. There must be clear-cut lines drawn between system administrator duties and computer user duties. These will vary from environment to environment and will depend on the level of security required within the environment. System and security administrators usually have the responsibility of installing and configuring software, performing backups and recovery procedures, setting permissions, adding and removing users, and developing user profiles. The computer user, on the other hand, may set or change passwords, create/edit/delete files, alter desktop configurations, and modify certain system parameters. The user should not be able to modify her own security profile, add and remove users globally, or make critical access decisions pertaining to network resources. This would breach the concept of separation of duties.

Privileged Account Management

Separation of duties also points to the need for *privileged account management* processes that formally enforce the principle of least privilege. A *privileged account* is one with elevated rights. When we hear this term, we usually think of system administrators, but it is important to consider that privileges often are gradually attached to user accounts for legitimate reasons but never reviewed again to see if they're still needed. In some cases, regular users end up racking up significant (and risky) permissions without anyone being aware of it (known as *authorization creep*).

More commonly, you will hear this concept under the label of *privileged account management (PAM)* because many organizations have very granular, role-based access controls. PAM consists of the policies and technologies used by an organization to control elevated (or privileged) access to any asset. It consists of processes for addressing the needs for individual elevated privileges, periodically reviewing those needs, reducing them to least privilege when appropriate, and documenting the whole thing.

Job Rotation

Job rotation means that, over time, more than one person fulfills the tasks of one position within the organization. This enables the organization to have more than one person who understands the tasks and responsibilities of a specific job title, which provides backup and redundancy if a person leaves the organization or is absent. Job rotation also helps identify fraudulent activities, and therefore can be considered a detective type of control. If Keith has performed David's position, Keith knows the regular tasks and routines that must be completed to fulfill the responsibilities of that job. Thus, Keith is better able to identify whether David does something out of the ordinary and suspicious.

A related practice is *mandatory vacations*. Chapter 1 touched on reasons to make sure employees take their vacations. Reasons include being able to identify fraudulent activities and enabling job rotation to take place. If an accounting employee has been performing a "salami attack" by shaving off pennies from multiple accounts and putting the money into his own account, the employee's company would have a better chance of figuring this out if that employee is required to take a vacation for a week or longer. When the employee is on vacation, another employee has to fill in. She might uncover questionable documents and clues of previous activities, or the company may see a change in certain patterns once the employee who is committing fraud is gone for a week or two.

It is best for auditing purposes if the employee takes two contiguous weeks off from work, which allows more time for fraudulent evidence to appear. Again, the idea behind mandatory vacations is that, traditionally, those employees who have committed fraud are usually the ones who have resisted going on vacation because of their fear of being found out while away.

Service Level Agreements

As we discussed briefly in Chapter 2, a service level agreement (SLA) is a contractual agreement that states that a service provider guarantees a certain level of service. For example, a web server will be down for no more than 52 minutes per year (which is approximately a 99.99 percent availability). SLAs help service providers, whether they are an internal IT operation or an outsourcer, decide what type of availability technology is appropriate. From this determination, the price of a service or the budget of the IT operation can be set. Most frequently, organizations use SLAs with external service providers to guarantee specific performance and, if it is not delivered, to penalize (usually monetarily) the vendor.

The process of developing an internal SLA (that is, one between the IT operations team and one or more internal departments) can also be beneficial to an organization. For starters, it drives a deeper conversation between IT and whoever is requesting the service. This alone can help both sides get a clearer understanding of the opportunities and threats the service brings with it. The requestor will then better understand the tradeoffs between service levels and costs and be able to negotiate the most cost-effective service with the IT team. The IT team can then use this dialogue to justify resources such as budget or staffing. Finally, internal SLAs allow all parties to know what "right" looks like.

Whether the SLA is internal or external, the organization must collect metrics to determine whether or not it is being met. After all, if nobody measures the service, what's the point of requiring a certain level of it? Identifying these metrics, in and of itself, allows the organization to determine whether a particular requirement is important or not. If both parties are having a hard time figuring out how much scheduled downtime is acceptable, that requirement probably doesn't need to be included in the SLA.

Change Management

The Greek philosopher Heraclitus said that "the only constant in life is change," and most of us would agree with him, especially when it comes to IT and security operations in our organizations. Change is needed to remain relevant and competitive, but it can bring risks that we must carefully manage. *Change management*, from an IT perspective, is the practice of minimizing the risks associated with the addition, modification, or removal of anything that could have an effect on IT services. This includes obvious IT actions like adding new software applications, segmenting LANs, and retiring network services. But it also includes changes to policies, procedures, staffing, and even facilities. Consequently, any change to security controls or practices probably falls under the umbrella of change management.

Change Management Practices

Well-structured change management practices are essential to minimizing the risks of changes to an environment. The process of devising these practices should include representatives for all stakeholders, so it shouldn't just be limited to IT and security staff. Most organizations that follow this process formally establish a group that is responsible for approving changes and overseeing the activities of changes that take place within the organization. This group can go by one of many names, but for this discussion we will refer to it as the change advisory board (CAB).

The CAB and change management practices should be laid out in the change management policy. Although the types of changes vary, a standard list of procedures can help keep the process under control and ensure it is carried out in a predictable manner. The following steps are examples of the types of procedures that should be part of any change management policy:

- **Request for a change to take place** The individual requesting the change must do so in writing, justify the reasons, clearly show the benefits and possible pitfalls of (that is, risk introduced by) the change. The Request for Change (RFC) is the standard document for doing this and contains all information required to approve a change.
- **Evaluate the change** The CAB reviews the RFC and analyzes its potential impacts across the entire organization. Sometimes the requester is asked to conduct more research and provide more information before the change is approved. The CAB then completes a change evaluation report and designates the individual or team responsible for planning and implementing the change.
- **Plan the change** Once the change is approved, the team responsible for implementing it gets to work planning the change. This includes figuring out all the details of how the change interfaces with other systems or processes, developing a timeline, and identifying specific actions to minimize the risks. The change must also be fully tested to uncover any unforeseen results. Regardless of how well we test, there is always a chance that the change will cause an unacceptable loss or outage, so every change request should also have a rollback plan that restores the system to the last known-good configuration.

- **Implementation** Once the change is planned and fully tested, it is implemented and integrated into any other affected processes and systems. This may include reconfiguring other systems, changing or developing policies and procedures, and providing training for affected staff. These steps should be fully documented and progress should be monitored.
- **Review the change** Once the change is implemented, it is brought back to the CAB for a final review. During this step, the CAB verifies that the change was implemented as planned, that any unanticipated consequences have been properly addressed, and that the risks remain within tolerable parameters.
- **Close or sustain** Once the change is implemented and reviewed, it should be entered into a change log. A full report summarizing the change may also be submitted to management, particularly for changes with large effects across the organization.

These steps, of course, usually apply to large changes that take place within an organization. These types of changes are typically expensive and can have lasting effects on an organization. However, smaller changes should also go through some type of change control process. If a server needs to have a patch applied, it is not good practice to have an engineer just apply it without properly testing it on a nonproduction server, without having the approval of the IT department manager or network administrator, and without having backup and backout plans in place in case the patch causes some negative effect on the production server. Of course, these changes still need to be documented. For this reason, ITIL 4 (introduced in Chapter 4) specifies three types of changes that follow the same basic process but tailored for specific situations:

- **Standard changes** Preauthorized, low-risk changes that follow a well-known procedure. Examples include patching a server or adding memory or storage to it.
- **Emergency changes** Changes that must be implemented immediately. Examples include implementing a security patch for a zero-day exploit or isolating the network from a DDoS attack.
- **Normal changes** All other changes that are not standard changes or emergency changes. Examples include adding a server that will provide new functionality or introducing a new application to (or removing a legacy one from) the golden image.

Regardless of the type of change, it is critical that the operations department create approved backout plans before implementing changes to systems or the network. It is very common for changes to cause problems that were not properly identified before the implementation process began. Many network engineers have experienced the headaches of applying poorly developed “fixes” or patches that end up breaking something else in the system. Developing a backout plan ensures productivity is not negatively affected by these issues. This plan describes how the team will restore the system to its original state before the change was implemented.

Change Management Documentation

Failing to document changes to systems and networks is only asking for trouble, because no one will remember, for example, what was done to that one server in the demilitarized zone (DMZ) six months ago or how the main router was fixed when it was acting up last year. Changes to software configurations and network devices take place pretty often in most environments, and keeping all of these details properly organized is impossible, unless someone maintains a log of this type of activity.

Numerous changes can take place in an organization, some of which are as follows:

- New computers installed
- New applications installed
- Different configurations implemented
- Patches and updates installed
- New technologies integrated
- Policies, procedures, and standards updated
- New regulations and requirements implemented
- Network or system problems identified and fixes implemented
- Different network configurations implemented
- New networking devices integrated into the network
- Company acquired by, or merged with, another company

The list could go on and on and could be general or detailed. Many organizations have experienced some major problem that affects the network and employee productivity. The IT department may run around trying to figure out the issue and go through hours or days of trial-and-error exercises to find and apply the necessary fix. If no one properly documents the incident and what was done to fix the issue, the organization may be doomed to repeat the same scramble six months to a year down the road.

Configuration Management

At every point in the O&M part of assets' life cycles (which we discussed in Chapter 5), we need to also ensure that we get (and keep) a handle on how these assets are configured. Sadly, most default configurations are woefully insecure. This means that if we do not configure security when we provision new hardware or software, we are virtually guaranteeing successful attacks on our systems. *Configuration management (CM)* is the process of establishing and maintaining consistent configurations on all our systems to meet organizational requirements.

Configuration management processes vary among organizations but have certain elements in common. Virtually everyone that practices it starts off by defining and establishing organization-wide agreement on the required configurations for all systems in the scope of the effort. At a minimum, this should include the users' workstations and all business-critical systems. These configurations are then applied to all systems. There will be exceptions, of course, and special requirements that lead to nonstandard configurations, which need to be approved by the appropriate individuals and documented. There will also be changes over time, which should be dealt with through the change management practices defined in the previous section. Finally, configurations need to be periodically audited to ensure continued compliance with them.

Baselining

A *baseline* is the configuration of a system at a point in time as agreed upon by the appropriate decision makers. For a typical user workstation, a baseline defines the software that is installed (both operating system and applications), policies that are applied (e.g., disabling USB thumb drives), and any other configuration setting such as the domain name, DNS server address, and many others. Baselining allows us to build a system once, put it through a battery of tests to ensure it works as expected, and then provision it out consistently across the organization.

In a perfect world, all systems that provide the same functionality are configured identically. This makes it easier to manage them throughout their life cycles. As we all know, however, there are plenty of exceptions in the real world. System configuration exceptions often have perfectly legitimate business reasons, so we can't just say "no" to exception requests and keep our lives simple. The system baseline allows us to narrow down what makes these exceptional systems different. Rather than document every single configuration parameter again (which could introduce errors and omissions), all we have to do is document what is different from a given baseline.

Baselines do more than simply tell us what systems (should) look like at a given point in time; they also document earlier configuration states for those systems. We want to keep old baselines around because they tell the story of how a system evolved. Properly annotated, baselines tell us not only the "what" but also the "why" of configurations over time.

A related concept to baselining is the golden image, which is a preconfigured, standard template from which all user workstations are provisioned. A golden image is known by many other names including gold master, clone image, master image, and base image. Whatever name you use, it saves time when provisioning systems because all you have to do is clone the image onto a device, enter a handful of parameters unique to the system (such as the hostname), and it's ready for use. Golden images also improve security by consistently applying security controls to every cloned system. Another advantage is a reduction in configuration errors, which also means a lower risk of inadvertently introduced vulnerabilities.

Provisioning

We already addressed secure provisioning in Chapter 5 but the topic bears revisiting in the context of configuration management. Recall that provisioning is the set of all activities required to provide one or more new information services to a user or group of users ("new" meaning previously not available to that user or group). Technically, provisioning and

Configuration Management vs. Change Management

Change management is a *business* process aimed at deliberately regulating the changing nature of business activities such as projects or IT services. It is concerned with issues such as changing the features in a system being developed or changing the manner in which remote workers connect to the internal network. While IT and security personnel are involved in change management, they are usually not in charge of it.

Configuration management is an *operational* process aimed at ensuring that controls are configured correctly and are responsive to the current threat and operational environments. As an information security professional, you would likely lead in configuration management but simply participate in change management processes.

configuration are two different but related activities. Provisioning generally entails acquiring, installing, and launching a new service. Depending on how this is done, that service may still need to be configured (and possibly even baselined).

Automation

As you can imagine, configuration management requires tracking and updating a lot of information on many different systems. This is why mature organizations leverage automation for many of the required tasks, including maintaining individual configuration items in a *configuration management database (CMDB)*. The CMDB can store information about all organizational assets, their baselines, and their relationships to one another. Importantly, a CMDB provides versioning so that, if a configuration error is made, reverting to a previous baseline is easy.

More elaborate automation tools are capable of not only tracking configurations but also provisioning systems that implement them. Perhaps the best-known tool in this regard, particularly for virtualized or cloud infrastructures, is Ansible, which is an open-source configuration management, deployment, and orchestration tool. Through the use of playbooks written in YAML (which, recursively, stands for "YAML Ain't Markup Language"), Ansible allows automated asset provisioning and configuration.

Resource Protection

In Chapter 5, we defined assets as anything of worth to the organization. A related concept is a *resource*, which is anything that is required to perform an activity or accomplish a goal. So, a resource can also be an asset if you own it and it has inherent value to you. In the context of security operations, a resource is anything the organization needs to accomplish any of its tasks. This includes hardware, software, data, and the media on which the last two are stored.

EXAM TIP Though assets and resources are, technically, slightly different things, you should treat them as synonymous in the exam.

We will discuss how to protect hardware resources later in this chapter when we cover physical security. Though we already covered software, data, and media protections in Chapter 6, the topic is worth revisiting as it applies to managing security operations. There are three types of digital resources that are of particular interest in this regard: system images, source files, and backups.

System Images

Because system images are essential to efficiently provisioning systems, they are a key resource both during normal operations and when we are responding to a security incident. Presumably, the images we use to clone new (or replacement) systems are secure because (as a best practice) we put a lot of work into hardening them and ensuring they contain no known vulnerabilities. However, if adversaries were able to modify the images so as to introduce vulnerabilities, they would have free access to any system provisioned using the tainted images. Similarly, if the images were destroyed (deliberately, accidentally, or through an act of nature), recovering from a large-scale incident would be much more difficult and time-consuming.

Source Files

If the images were unavailable or otherwise compromised, we would have to rebuild everything from scratch. There are also cases in which we just need to install specific software. Either way, we need reliable source files. Source files contain the code that executes on a computer to provide applications or services. This code can exist in either executable form or as a sequence of statements in a high-level language such as C/C++, Java, or Python. Either way, it is possible for adversaries to insert malicious code into source files so that any system provisioned using them will be vulnerable. Worse yet, if you work for a software company with clients around the world, your company may be a much more interesting target for advanced persistent threats (APTs) who may want to compromise your software to breach your customers. This kind of software supply-chain attack is best exemplified by the SolarWinds attack of 2020.

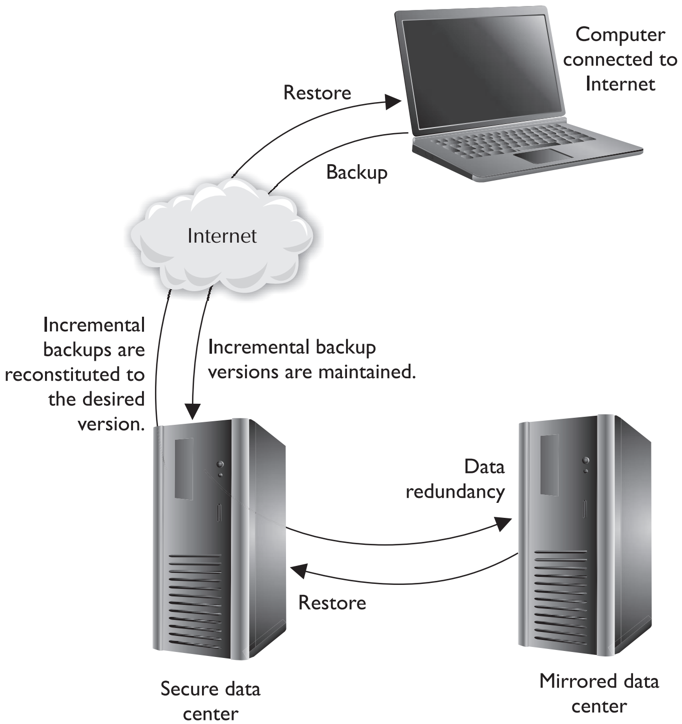
Even if your organization is not likely to be targeted by APTs, you are probably concerned about ransomware attacks. Having good backups is the key to quickly recovering from ransomware (without having to pay the ransom), but it hinges on the integrity and availability of the backup data. Many cybercriminals deliberately look for backups and encrypt them also to force their victims to pay the ransom.

Backups

Backing up software and having backup hardware devices are two large parts of network availability. You need to be able to restore data if a hard drive fails, a disaster takes place, or some type of software corruption occurs.

Every organization should develop a policy that indicates what gets backed up, how often it gets backed up, and how these processes should occur. If users have important information on their workstations, the operations department needs to develop a method that indicates that backups include certain directories on users' workstations or that users move their critical data to a server share at the end of each day to ensure it gets backed up. Backups may occur once or twice a week, every day, or every three hours. It is up to the organization to determine this interval. The more frequent the backups, the more resources will be dedicated to it, so there needs to be a balance between backup costs and the actual risk of potentially losing data.

An organization may find that conducting automatic backups through specialized software is more economical and effective than spending IT work-hours on the task. The integrity of these backups needs to be checked to ensure they are happening as expected—rather than finding out right after two major servers blow up that the automatic backups were saving only temporary files.



Protecting Backups from Ransomware

The best way to minimize your risks due to ransomware is to have effective backups that are beyond the reach of the cybercriminals and can quickly restore affected systems. This means putting the greatest distance (and security controls) possible between a system and its backups. Obviously, you should never store backups on the system itself or on a directly connected external drive. The following are some tips on how to keep your backups away from threat actors:

- *Use a different OS for your backup server.* Most ransomware today targets a single type of OS (mostly Windows). Even if the attack is not automated, threat actors are likelier to be proficient in whatever OS they are attacking, so having your backups managed by a system running a different OS automatically gives you a leg up.
- *Get your backups out of town.* Whatever you do, make sure your backups are not on a drive that is directly attached to the asset you are protecting, or even on the same LAN segment (like in the same data center). The more distance, the better, especially if you can layer controls like ACLs or even use data diodes. We know of data so sensitive that its backups are physically transported to other states or countries periodically.
- *Go old school.* Consider using older technologies like optical discs and magnetic tapes. You may get some weird looks from your early-adopter colleagues, but you may save the day when things go sideways on you.
- *Protect your backups like your career depends on it.* (It may!) Stay up to date on the latest techniques cybercriminals are using to attack backups and ensure you have adequate controls in place to prevent them from being effective.

Hierarchical Storage Management

Hierarchical storage management (HSM) provides continuous online backup functionality. It combines hard disk technology with the cheaper and slower optical or tape jukeboxes. The HSM system dynamically manages the storage and recovery of files, which are copied to storage media devices that vary in speed and cost. The faster media holds the files that are accessed more often, and the seldom-used files are stored on the slower devices, or *near-line* devices, as shown in Figure 20-1. The storage media could include optical discs, magnetic disks, and tapes. This functionality happens in the background without the knowledge of the user or any need for user intervention.

HSM works, according to tuning based on the trade-off between the cost of storage and the availability of information, by migrating the actual content of less used files to lower-speed, lower-cost storage, while leaving behind a “stub,” which looks to the user like it contains the full data of the migrated file. When the user or an application accesses the stub, the HSM uses the information in the stub to find the real location of the information and then retrieve it transparently for the user.

This type of technology was created to save money and time. If all data was stored on hard drives, that would be expensive. If a lot of the data was stored on tapes, it would take too long to retrieve the data when needed. So HSM provides a terrific approach by providing you with the data you need, when you need it, without having to bother the administrator to track down some tape or optical disc.

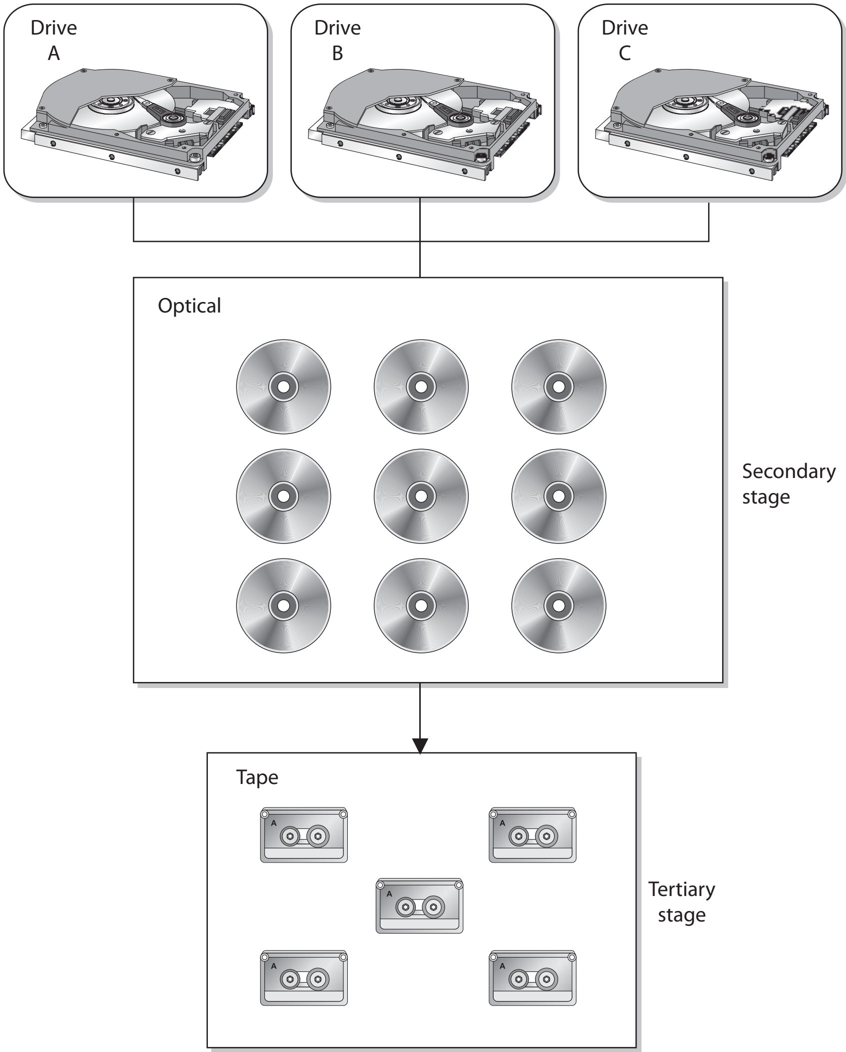


Figure 20-1 HSM provides an economical and efficient way of storing data.

Backups should include the underlying operating system and applications, as well as the configuration files for both. Systems are attached to networks, and network devices can experience failures and data losses as well. Data loss of a network device usually means the configuration of the network device is lost completely (and the device will not even boot up), or that the configuration of the network device reverts to defaults (which, though it will boot up, does your network little good). Therefore, the configurations of network and other nonsystem devices (for example, the phone system) in the environment are also necessary.

Vulnerability and Patch Management

Dealing with new vulnerabilities and their corresponding patches is an inevitability in cybersecurity. The trick is to deal with these in an informed and deliberate manner. While the following sections treat vulnerability management and patch management separately, it is important to consider them as two pieces of the same puzzle in real life. We may learn of a new vulnerability for which a patch does not yet exist. Equally bad would be applying a patch that brings down a critical business system. For these reasons (among many others), we should manage vulnerabilities and patches in a synchronized and coordinated manner across our organizations.

Vulnerability Management

No sufficiently complex information system can ever be completely free of vulnerabilities. *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. Many people equate vulnerability management with periodically running a vulnerability scanner against their systems, but the process must include more than just that. Vulnerabilities exist not only in software, which is what the scanners assess, but also in business processes and in people. Flawed business processes, such as sharing proprietary information with parties who have not signed a nondisclosure agreement (NDA), cannot be detected by vulnerability scanners. Nor can they detect users who click malicious links in e-mails. What matters most is not the tool or how often it is run, but having a formal process that looks at the organization holistically and is closely tied to the risk management process.

Vulnerability management is part of our risk management process. We identify the things that we have that are of value to us and the threat actors that might take those away from us or somehow interfere with our ability to benefit from them. Then we figure out how these actors might go about causing us losses (in other words, exploiting our vulnerabilities) and how likely these events might be. As we discussed in Chapter 2, this gives us a good idea of our risk exposure. The next step is to decide which of those risks we will address and how. The "how" is typically through the application of a security control. Recall that we can never bring our risk to zero, which means we will always have vulnerabilities for which we have no effective controls. These unmitigated risks exist because we think the chance of them being realized or their impact on the organization (or both) is low enough for the risk to be tolerable. In other words, the cost of mitigating the risk is not worth the return on our investment. For those risks, the best we can do is continually monitor for changes in their likelihood or potential impact.

As you can see, vulnerability management is all about finding vulnerabilities, understanding their impact on the organization, and determining what to do about them. Since information system vulnerabilities can exist in software, processes, or people, it is worthwhile to discuss how we implement and support vulnerability management in each of these areas.

Software Vulnerabilities

Vulnerabilities are usually discovered by security researchers who notify vendors and give them some time (at least two weeks) to work on a patch before the researchers make their findings public. This is known as responsible or ethical disclosure. The Computer Emergency Response Team Coordination Center (CERT/CC) is the main clearinghouse for vulnerability disclosures. Once a vulnerability is discovered, vulnerability scanner vendors release plug-ins for their tools. These plug-ins are essentially simple programs that look for the presence of one specific flaw.

NOTE Some organizations have their own in-house vulnerability research capability or can write their own plug-ins. In our discussion, we assume the more general case in which vulnerability scanning is done using third-party commercial tools whose licenses include subscriptions to vulnerability feeds and related plug-ins.

As previously mentioned, software vulnerability scanning is what most people think of when they hear the term vulnerability management. Scanning is simply a common type of vulnerability assessment that can be divided into four phases:

1. **Prepare** First, you have to determine the scope of the vulnerability assessment. What are you testing and how? Having defined the scope, you schedule the event and coordinate it with affected asset and process owners to ensure it won't interfere with critical business processes. You also want to ensure you have the latest vulnerability signatures or plug-ins for the systems you will be testing.
2. **Scan** For best results, the scan is automated, follows a script, and happens outside of the regular hours of operation for the organization. This reduces the chance that something goes unexpectedly wrong or that you overlook a system. During the scan, it is helpful to monitor resource utilization (like CPU and bandwidth) to ensure you are not unduly interfering with business operations.
3. **Remediate** In a perfect world, you don't find any of the vulnerabilities for which you were testing. Typically, however, you find a system that somehow slipped through the cracks, so you patch it and rescan just to be sure. Sometimes, however, there are legitimate business reasons why a system can't be patched (at least right away), so remediation may require deploying a compensating control or (in the worst case) accepting the risk as is.
4. **Document** This important phase is often overlooked because some organizations rely on the reports that are automatically generated by the scanning tools. These reports, however, don't normally include important details like why a vulnerability may intentionally be left unpatched, the presence of compensating controls elsewhere, or the need for more/less frequent scanning of specific systems. Proper documentation ensures that assumptions, facts, and decisions are preserved to inform future decisions.

Process Vulnerabilities

A process vulnerability exists whenever there is a flaw or weakness in a business process, independent of the use of automation. For example, suppose a user account provisioning process requires only an e-mail from a supervisor asking for an account for the new hire. Since e-mail messages can be spoofed, a threat actor could send a fake e-mail impersonating a real supervisor. If the system administrator creates the account and responds with the new credentials, the adversary would now have a legitimate account with whatever authorizations were requested.

Process vulnerabilities frequently are overlooked, particularly when they exist at the intersection of multiple departments within the organization. In the example, the account provisioning process vulnerability exists at the intersection of a business area (where the fictitious user will supposedly work), IT, and human resources.

A good way to find process vulnerabilities is to periodically review existing processes using a red team. As introduced in Chapter 18, a red team is a group of trusted individuals whose job is to look at something from an adversary's perspective. Red teaming is useful in many contexts, including identifying process vulnerabilities. The red team's task in this context would be to study the processes, understand the organization's environment, and then look for ways to violate its security policies. Ideally, red team exercises should be conducted whenever any new process is put in place. Realistically, however, these events take place much less frequently (if at all).

NOTE The term *red team exercise* is often used synonymously with *penetration test*. In reality, a red team exercise can apply to any aspect of an organization (people, processes, facilities, products, ideas, information systems) and aims to emulate the actions of threat actors seeking specific objectives. A penetration test, on the other hand, is focused on testing the effectiveness of security controls in facilities and/or information systems.

Human Vulnerabilities

By many accounts, over 90 percent of security incidents can be traced back to a member of an organization doing something they shouldn't have, maliciously or otherwise. This implies that if your vulnerability management is focused exclusively on hardware and software systems, you may not be reducing your attack surface by much. A common approach to managing human vulnerabilities is social engineering assessments. We briefly introduced social engineering in Chapter 18 as a type of attack but return to it now as a tool in your vulnerability management toolkit.

Chris Hadnagy, one of the world's leading experts on the subject, defines social engineering as "the act of manipulating a person to take an action that *may* or *may not* be in the 'target's' best interest." A social engineering assessment involves a team of trained personnel attempting to exploit vulnerabilities in an organization's staff. This could result in targets revealing sensitive information, allowing the social engineers into restricted areas, clicking malicious links, or plugging into their computer a thumb drive laden with malware.

A social engineering assessment, much like its nefarious counterpart, consists of three phases:

1. **Open-source intelligence (OSINT) collection** Before manipulating a target, the social engineer needs to learn as much as possible about that person. This phase is characterized by searches for personal information in social media sites; web searches; and observation, eavesdropping, and casual conversations. Some OSINT tools allow quick searches of a large number of sources for information on specific individuals or organizations.
2. **Assessment planning** The social engineer could go on gathering OSINT forever but at some point (typically very quickly) will have enough information to formulate a plot to exploit one or more targets. Some people respond emotionally to certain topics, while others may best be targeted by impersonating someone in a position of authority. The social engineer identifies the kinds of engagements, topics, and pretexts that are likeliest to work against one or more targets.
3. **Assessment execution** Regardless of how well planned an assessment may be, we know that no plan survives first contact. Social engineers have to think quickly on their feet and be very perceptive of their targets' states of mind and emotions. In this phase, they engage targets through some combination of personal face-to-face, telephonic, text, or e-mail exchange and persuade them to take some action that compromises the security of the organization.

Rarely is a social engineering assessment not effective. At the end of the event, the assessors report their findings and use them to educate the organization on how to avoid falling for these tricks. Perhaps the most common type of assessment is in the form of phishing, but a real human vulnerability assessment should be much more comprehensive.

Patch Management

According to NIST Special Publication 800-40, Revision 3, *Guide to Enterprise Patch Management Technologie*s, patch management is "the process for identifying, acquiring, installing, and verifying patches for products and systems." *Patches* are software updates intended to remove a vulnerability or defect in the software, or to provide new features or functionality for it. Patch management is, at least in a basic way, an established part of organizations' IT or security operations already.

Unmanaged Patching

One approach to patch management is to use a decentralized or unmanaged model in which each software package on each device periodically checks for updates and, if any are available, automatically applies them. While this approach may seem like a simple solution to the problem, it does have significant issues that could render it unacceptably risky for an organization. Among these risks are the following:

- **Credentials** Installing patches typically requires users to have admin credentials, which violates the principle of least privilege.
- **Configuration management** It may be difficult (or impossible) to attest to the status of every application in the organization, which makes configuration management much more difficult.
- **Bandwidth utilization** Having each application or service independently download the patches will lead to network congestion, particularly if there is no way to control when this will happen.
- **Service availability** Servers are almost never configured to automatically update themselves because this could lead to unscheduled outages that have a negative effect on the organization.

There is almost no advantage to decentralized patch management, except that it is better than doing nothing. The effort saved by not having management overhead is more than balanced by the additional effort you'll have to put into responding to incidents and solving configuration and interoperability problems. Still, there may be situations in which it is not possible to actively manage some devices. For instance, if your users are allowed to work from home using personal devices, then it would be difficult to implement the centralized approach we discuss next. In such situations, the decentralized model may be the best to take, provided you also have a way to periodically (say, each time users connect back to the mother ship) check the status of their updates.

Centralized Patch Management

Centralized patch management is considered a best practice for security operations. There are multiple approaches to implementing it, however, so you must carefully consider the pluses and minuses of each. The most common approaches are

- **Agent based** An update agent is installed on each device. This agent communicates with one or more update servers and compares available patches with software and versions on the local host, updating as needed.
- **Agentless** One or more hosts remotely connect to each device on the network using admin credentials and check the remote device for needed updates. A spin on this is the use of Active Directory objects in a domain controller to manage patch levels.
- **Passive** Depending on the fidelity that an organization requires, it may be possible to passively monitor network traffic to infer the patch levels on each networked application or service. While minimally intrusive to the end devices, this approach is also the least effective since it may not always be possible to uniquely identify software versions through their network traffic artifacts.

Regardless of the approach you take, you want to apply the patches as quickly as possible. After all, every day you delay is an extra day that your adversaries have to exploit your vulnerabilities. The truth is that you can't (or at least shouldn't) always roll out the patch as soon as it comes out. There is no shortage of reports of major outages caused by rolling out patches without first testing their effects. Sometimes the fault lies with the vendor, who, perhaps in its haste to remove a vulnerability, failed to properly test that the patch wouldn't break any other functionality of the product. Other times the patch may be rock solid and yet have a detrimental second- or third-order effect on other systems on your hosts or networks. This is why testing the patch before rolling it out is a good idea.

Virtualization technologies make it easier to set up a patch test lab. At a minimum, you want to replicate your critical infrastructure (e.g., domain controller and production servers) in this virtual test environment. Most organizations also create at least one virtual machine (VM) that mimics each deployed operating system, with representative services and applications.

NOTE It is often possible to mitigate the risk created by a software vulnerability using other controls, such as rules for your firewalls, intrusion detection system (IDS), or intrusion protection system (IPS). This can buy time for you to test the patches. It also acts as a compensatory control.

Whether or not you are able to test the patches before pushing them out (and you really should), it is also a good idea to patch your subnets incrementally. It may take longer to get to all systems, but if something goes wrong, it will only affect a subset of

Reverse Engineering Patches

Zero-day exploits are able to successfully attack vulnerabilities that are not known to the software vendor or users of its software. For that reason, zero-day exploits are able to bypass the vast majority of controls such as firewalls, antimalware, and IDS/IPS. Though zero-day exploits are very powerful, they are also exceptionally hard to develop and very expensive to buy in the underground markets.

There is an easier and cheaper way for attackers to exploit recent vulnerabilities, and that is by reverse engineering the software patches that vendors push out. This approach takes advantage of the delay between a patch being available and it getting pushed to all the vulnerable computers in the organization. If the attacker can reverse engineer the patch faster than the defenders use it to update all computers, then the attacker wins. Some vendors are mitigating this threat by using *code obfuscation*, which, in an ironic turn of events, is a technique developed by attackers almost 30 years ago in an effort to thwart the then simple pattern-matching approach of antimalware solutions.

Even with code obfuscation, it is just a matter of time before the bad guys figure out what the vulnerability is. This puts pressure on the defenders to roll out the patches across the entire organization as quickly as possible. In this haste, organizations sometimes overlook problem indicators. Add to this a healthy application of Murphy's law and you see why it is imperative to have a way to deal with these unknowns. A *rollback plan* (previously discussed in the "Change Management" section of this chapter) describes the steps by which a change is reversed in order to restore functionality or integrity.

your users and services. This gradual approach to patching also serves to reduce network congestion that could result from all systems attempting to download patches at the same time. Obviously, the benefits of gradual patching need to be weighed against the additional exposure that the inherent delays will cause.

Physical Security

We already discussed physical security in Chapter 10, but our focus then was on the design of sites and facilities. The CISSP CBK breaks physical security into design, which falls under Domain 3 (Security Architecture and Engineering), and operations, which falls in the current Domain 7 (Security Operations). We follow the same approach here.

As with any other defensive technique, physical security should be implemented using the defense-in-depth secure design principle. For example, before an intruder can get to the written recipe for your company's secret barbeque sauce, she will need to climb or cut a fence, slip by a security guard, pick a door lock, circumvent a biometric access control reader that protects access to an internal room, and then break into the safe that holds the recipe. The idea is that if an attacker breaks through one control layer, there will be others in her way before she can obtain the company's crown jewels.

NOTE It is also important to have a diversity of controls. For example, if one key works on four different door locks, the intruder has to obtain only one key. Each entry should have its own individual key or authentication combination.

This defense model should work in two main modes: one mode during normal facility operations and another mode during the time the facility is closed. When the facility is closed, all doors should be locked with monitoring mechanisms in strategic positions to alert security personnel of suspicious activity. When the facility is in operation, security gets more complicated because authorized individuals need to be distinguished from unauthorized individuals. Perimeter security controls deal with facility and personnel access controls and with external boundary protection mechanisms. Internal security controls deal with work area separation and personnel badging. Both perimeter and internal security also address intrusion detection and corrective actions. The following sections describe the elements that make up these categories.

External Perimeter Security Controls

Your first layer of defense is your external perimeter. This could be broken down into distinct, concentric areas of increasing security. Let's consider an example taken from the *Site Security Design Guide*, published by the U.S. General Services Administration (GSA) Public Buildings Service, which is shown in Figure 20-2. In it, we see the entire site is fenced off, which actually creates two security zones: the (external) neighborhood (zone 1) and the standoff perimeter (zone 2). Depending on risk levels, the organization may want to restrict site access and parking by creating a third zone. Even if the risk is fairly low, it may be desirable to ensure that vehicles are unable to get too close to the building.

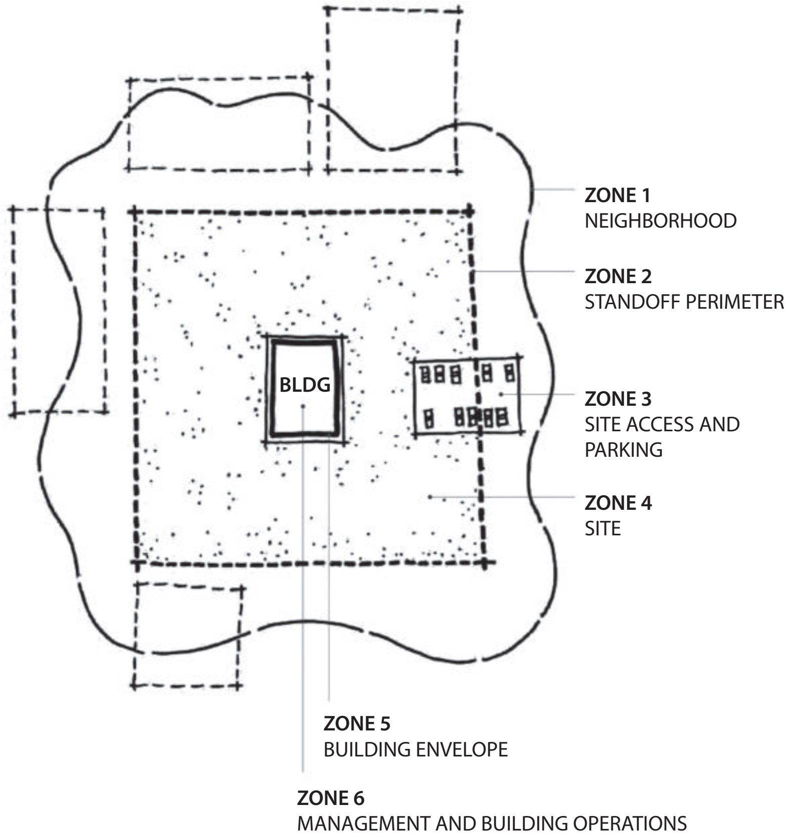


Figure 20-2 Security zones around a facility (Source: https://www.wbdg.org/FFC/GSA/site_security_dg.pdf)

This protects the facility against accidents, but also against explosions. (A good rule of thumb is to ensure there is a 200-foot standoff distance between any vehicles and buildings.) Then there is the rest of the enclosed site (zone 4), which could include break areas for employees, backup power plants, and anything else around the building exterior. Finally, there's the inside of the building, which we'll discuss later in this chapter. Each of these zones has its own set of requirements, which should be increasingly restrictive the closer someone gets to the building.

External perimeter security controls are usually put into place to provide one or more of the following services:

- Control pedestrian and vehicle traffic flows
- Provide various levels of protection for different security zones
- Establish buffers and delaying mechanisms to protect against forced entry attempts
- Limit and control entry points

These services can be provided by using the following control types (which are not all-inclusive):

- **Access control mechanisms** Locks and keys, an electronic card access system, personnel awareness
- **Physical barriers** Fences, gates, walls, doors, windows, protected vents, vehicular barriers
- **Intrusion detection** Perimeter sensors, interior sensors, annunciation mechanisms
- **Assessment** Guards, surveillance cameras
- **Response** Guards, local law enforcement agencies
- **Deterrents** Signs, lighting, environmental design

Several types of perimeter protection mechanisms and controls can be put into place to protect an organization's facility, assets, and personnel. They can deter would-be intruders, detect intruders and unusual activities, and provide ways of dealing with these issues when they arise. Perimeter security controls can be natural (hills, rivers) or manmade (fencing, lighting, gates). Landscaping is a mix of the two. In Chapter 10, we explored Crime Prevention Through Environmental Design (CPTED) and how this approach is used to reduce the likelihood of crime. Landscaping is a tool employed in the CPTED method. Sidewalks, bushes, and created paths can point people to the correct entry points, and trees and spiky bushes can be used as natural barriers. These bushes and trees should be placed such that they cannot be used as ladders or accessories to gain unauthorized access to unapproved entry points. Also, there should not be an overwhelming number of trees and bushes, which could provide intruders with places to hide. In the following sections, we look at the manmade components that can work within the landscaping design.

Fencing

Fencing can be quite an effective physical barrier. Although the presence of a fence may only delay dedicated intruders in their access attempts, it can work as a psychological deterrent by telling the world that your organization is serious about protecting itself.

Fencing can provide crowd control and helps control access to entrances and facilities. However, fencing can be costly and unsightly. Many organizations plant bushes or trees in front of the fencing that surrounds their buildings for aesthetics and to make the building less noticeable. But this type of vegetation can damage the fencing over time or negatively affect its integrity. The fencing needs to be properly maintained, because if a company has a sagging, rusted, pathetic fence, it is equivalent to telling the world that the company is not truly serious and disciplined about protection. But a nice, shiny, intimidating fence can send a different message—especially if the fencing is topped with three rungs of barbed wire.

When deciding upon the type of fencing, several factors should be considered. For example, when using metal fencing, the gauge of the metal should correlate to the types of physical threats the organization most likely faces. After carrying out the risk analysis (covered in Chapter 2), the physical security team should understand the probability of enemies attempting to cut the fencing, drive through it, or climb over or crawl under it. Understanding these threats will help the team determine the requirements for security fencing.

The risk analysis results will also help indicate what height of fencing the organization should implement. Fences come in varying heights, and each height provides a different level of security:

- Fences *three to four feet high* only deter casual trespassers.
- Fences *six to seven feet high* are considered too high to climb easily.
- Fences *eight feet high* (possibly with strands of barbed or razor wire at the top) deter the more determined intruder and clearly demonstrate your organization is serious about protecting its property.

The barbed wire on top of fences can be tilted in or out, which also provides extra protection. A prison would have the barbed wire on top of the fencing pointed in, which makes it harder for prisoners to climb and escape. Most organizations would want the barbed wire tilted out, making it harder for someone to climb over the fence and gain access to the premises.

Critical areas should have fences at least eight feet high to provide the proper level of protection. The fencing must be taut (not sagging in any areas) and securely connected to the posts. The fencing should not be easily circumvented by pulling up its posts.

Fencing: Gauges, Mesh Sizes, and Security

The gauge of fence wiring is the thickness of the wires used within the fence mesh. The lower the gauge number, the larger the wire diameter:

- **11 gauge** = 0.0907-inch diameter
- **9 gauge** = 0.1144-inch diameter
- **6 gauge** = 0.162-inch diameter

The mesh sizing is the minimum clear distance between the wires. Common mesh sizes are 2 inches, 1 inch, and 3/8 inch. It is more difficult to climb or cut fencing with smaller mesh sizes, and the heavier-gauged wiring is harder to cut. The following list indicates the strength levels of the most common gauge and mesh sizes used in chain-link fencing today:

- **Extremely high security** 3/8-inch mesh, 11 gauge
- **Very high security** 1-inch mesh, 9 gauge
- **High security** 1-inch mesh, 11 gauge
- **Greater security** 2-inch mesh, 6 gauge
- **Normal industrial security** 2-inch mesh, 9 gauge

> **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

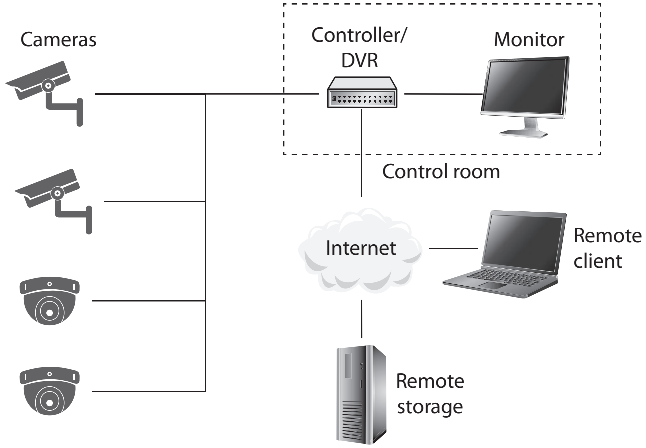


Figure 20-3 Several cameras can be connected to a DVR that can provide remote storage and access.

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.

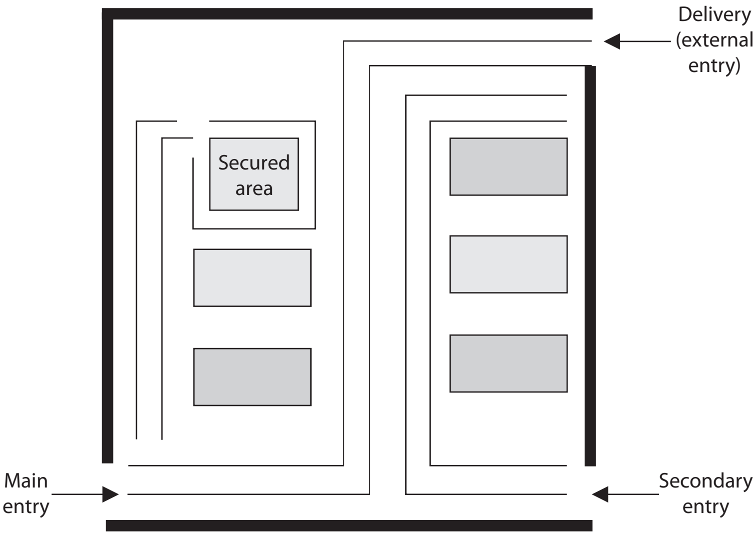


Figure 20-4 Access control points should be identified, marked, and monitored properly.

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.

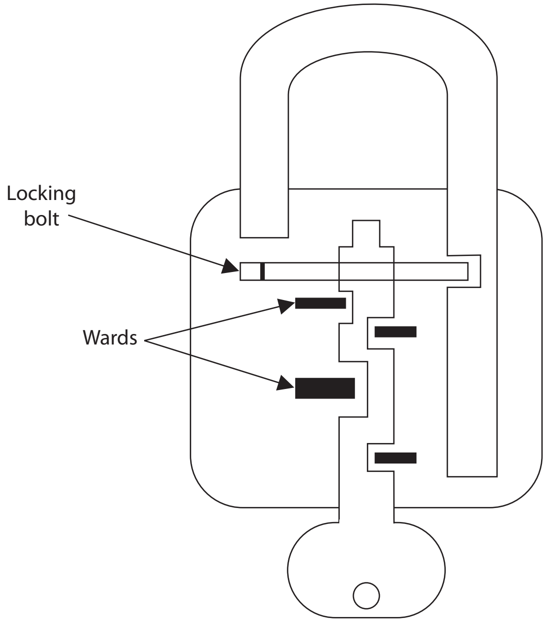
Mechanical Locks Two main types of mechanical locks are available: the warded lock and the tumbler lock. The warded lock is the basic padlock, as shown in Figure 20-5. It has a spring-loaded bolt with a notch cut in it. The key fits into this notch and slides the bolt from the locked to the unlocked 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.

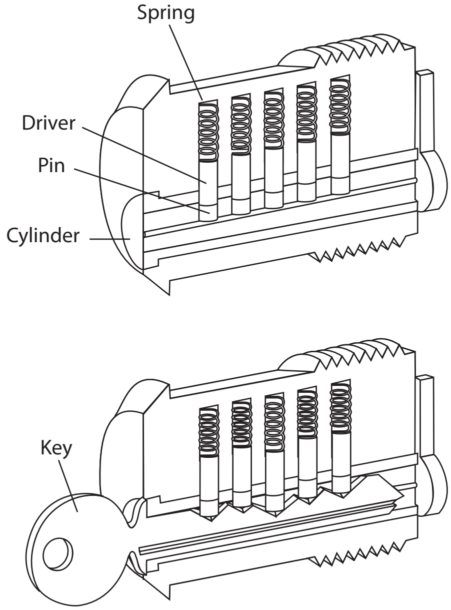
Figure 20-5
A warded lock

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.

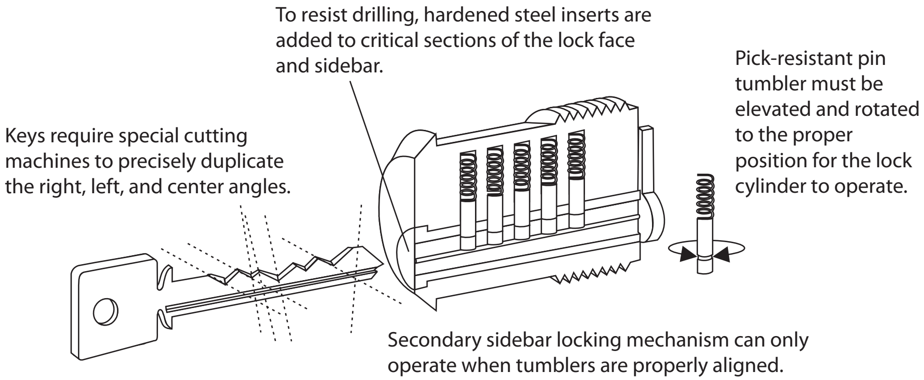
Lock Strengths

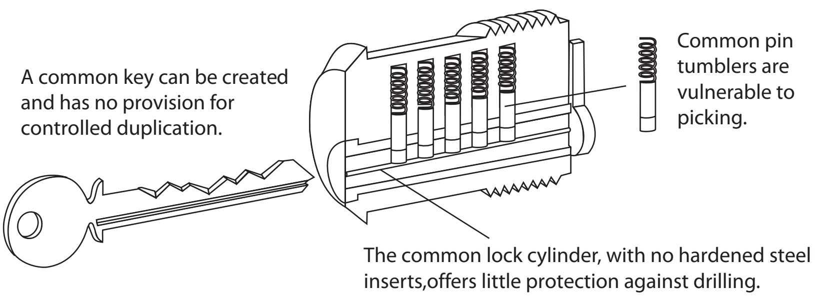
Basically, three grades of locks are available:

- **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.

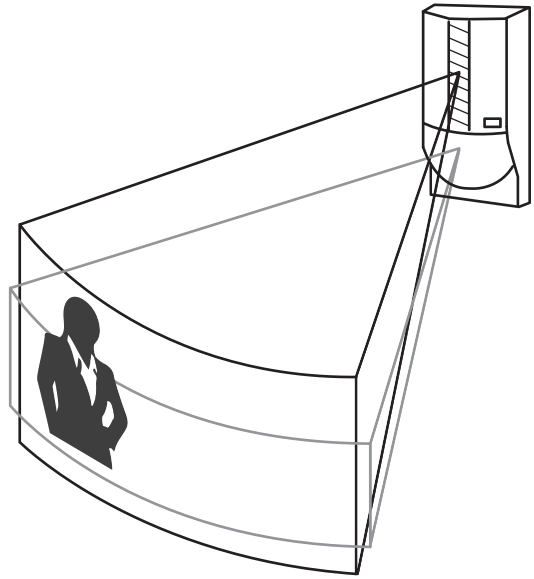


Figure 20-10 Different perimeter scanning devices work by covering a specific area.

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

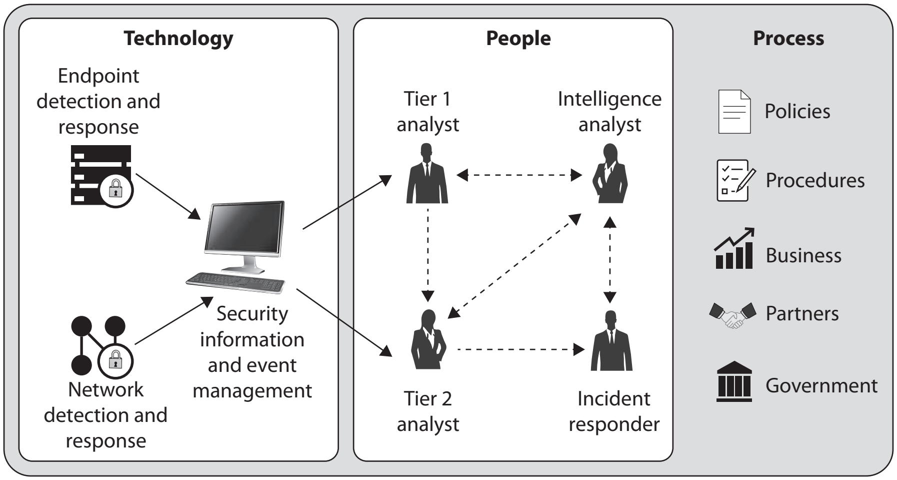


Figure 21-1 Core elements of a mature SOC

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.

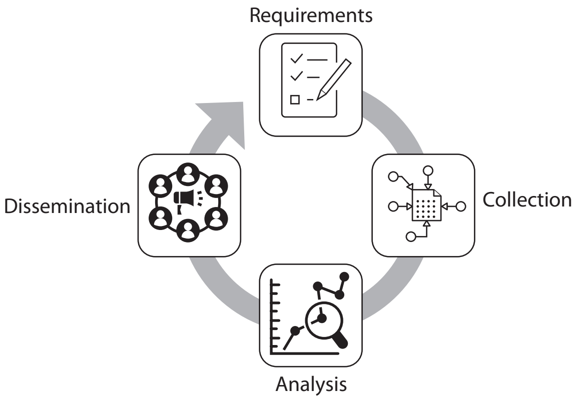
Threat Intelligence

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.

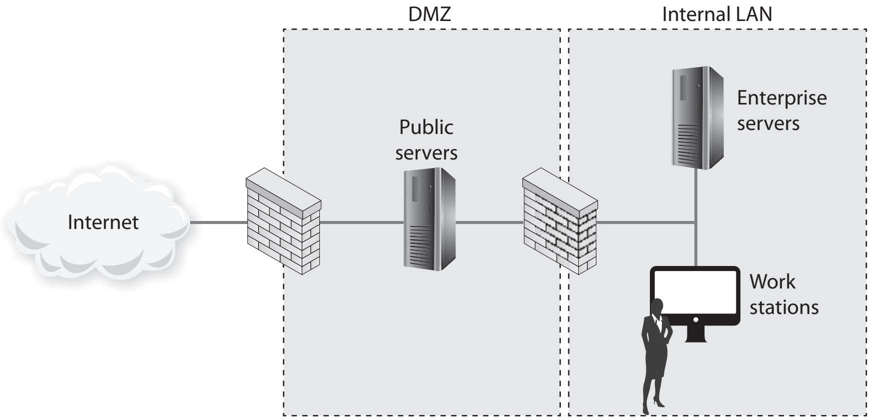


Figure 21-3 At least two firewalls, or firewall interfaces, are generally used to construct a DMZ.

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

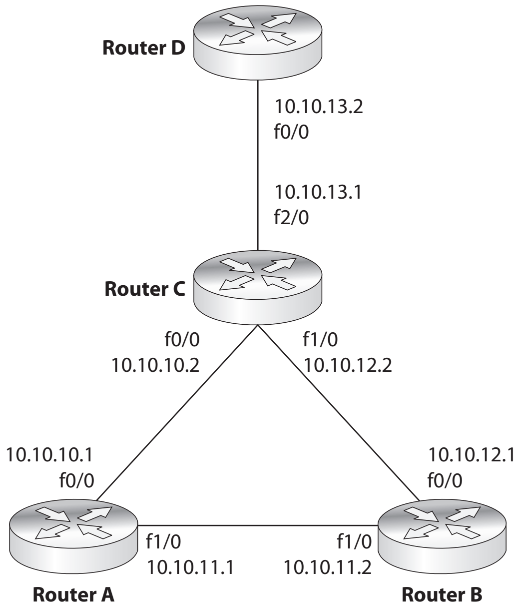
Packet filtering is a firewall technology that makes access decisions based upon network-level protocol header values. The device that is carrying out packet-filtering processes is configured with access control lists (ACLs), which dictate the type of traffic that is allowed into and out of specific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