Assets, Threats, and Vulnerabilities

Module 1 - Introduction to asset security

Introduction to assets

Security teams help companies by focusing on risk. In security, a risk is anything that can impact the confidentiality, integrity, or availability of an asset. Our primary focus as security practitioners is to maintain confidentiality, integrity, and availability, which are the three components of the CIA triad. The process of security risk planning is the first step toward protecting these cornerstones. Each organization has their own unique security plan based on the risk they face. Thankfully, you don't need to be familiar with every possible security plan to be a good security practitioner. All you really need to know are the basics of how these plans are put together.

Security plans are based on the analysis of three elements: assets, threats, and vulnerabilities. Organizations measure security risk by analyzing how each can have an effect on confidentiality, integrity, and availability of their information and systems. Basically, they each represent the what, why, and how of security. Let's spend a little time exploring each of these in more detail.

As you might imagine, an asset is an item perceived as having value to an organization. This often includes a wide range of things. Buildings, equipment, data, and people are all examples of assets that businesses want to protect. Let's examine this idea more by analyzing the assets of a home. Inside a home, there's a wide range of assets, like people and personal belongings. The outside structure of a home is made of assets too, like the walls, roof, windows, and doors. All of these assets have value, but they differ in how they might be protected. Someone might place a lower priority on protecting the outside walls than on the front door, for example. This is because a burglar is more likely to enter through the front door than a wall. That's why we have locks. With so many types of assets to think of, security plans need to prioritize resources. After all, no matter how large a security team is, it would be impossible to monitor every single asset at all hours of the day.

Security teams can prioritize their efforts based on threats. In security, a threat is any circumstance or event that can negatively impact assets. Much like assets, threats include a wide range of things. Going back to the example of a home, a threat can be a burglar who's trying to gain access. Burglars aren't the only type of threat that affect the security of windows and doors. What if either broke by accident? Strong winds can blow the door open during a bad storm. Or, kids playing with a ball nearby can accidentally damage a window. If any of these thoughts crossed your mind, great job! You're already demonstrating a security mindset.

The final element of a security plan that we're going to cover are vulnerabilities. In security, a vulnerability is a weakness that can be exploited by a threat. A weak lock on a front door, for example, is a vulnerability that can be exploited by a burglar. And old, cracked wood is a different vulnerability on that same front door that can increase the chances of storm damage. In other words, think of vulnerabilities as flaws within an asset. Assets can have many different types of vulnerabilities that are an easy target for attackers.

Security risk

Security plans are all about how an organization defines risk. However, this definition can vary widely by organization. As you may recall, a **risk** is anything that can impact the confidentiality, integrity, or availability of an asset. Since organizations have particular assets that they value, they tend to differ in how they interpret and approach risk.

One way to interpret risk is to consider the potential effects that negative events can have on a business. Another way to present this idea is with this calculation:

Likelihood x Impact = Risk

For example, you risk being late when you drive a car to work. This negative event is more likely to happen if you get a flat tire along the way. And the impact could be serious, like losing your job. All these factors influence how you approach commuting to work every day. The same is true for how businesses handle security risks.

In general, we calculate risk in this field to help:

- Prevent costly and disruptive events
- Identify improvements that can be made to systems and processes
- Determine which risks can be tolerated
- Prioritize the critical assets that require attention

The business impact of a negative event will always depend on the asset and the situation. Your primary focus as a security professional will be to focus on the likelihood side of the equation by dealing with certain factors that increase the odds of a problem.

Risk factors

As you'll discover throughout this course, there are two broad risk factors that you'll be concerned with in the field:

- Threats
- Vulnerabilities

The risk of an asset being harmed or damaged depends greatly on whether a threat takes advantage of vulnerabilities.

Let's apply this to the risk of being late to work. A threat would be a nail puncturing your tire, since tires are vulnerable to running over sharp objects. In terms of security planning, you would want to reduce the likelihood of this risk by driving on a clean road.

Categories of threat

Threats are circumstances or events that can negatively impact assets. There are many different types of threats. However, they are commonly categorized as two types: intentional and unintentional.

For example, an *intentional* threat might be a malicious hacker who gains access to sensitive information by targeting a misconfigured application. An *unintentional* threat might be an employee who holds the door open for an unknown person and grants them access to a restricted area. Either one can cause an event that must be responded to.

Categories of vulnerability

Vulnerabilities are weaknesses that can be exploited by threats. There's a wide range of vulnerabilities, but they can be grouped into two categories: technical and human.

For example, a *technical* vulnerability can be misconfigured software that might give an unauthorized person access to important data. A *human* vulnerability can be a forgetful employee who loses their access card in a parking lot. Either one can lead to risk.

Security starts with asset classification

A fundamental truth of security is you can only protect the things you account for. Asset management is the process of tracking assets and the risks that affects them. All security plans revolve around asset management. Recall that assets include any item perceived as having value to an organization. Equipment, data, and intellectual property are just a few of the wide range of assets businesses want to protect. A critical part of every organization's security plan is keeping track of its assets.

Asset management starts with having an asset inventory, a catalog of assets that need to be protected. This is a central part of protecting organizational assets. Without this record, organizations run the risk of losing track of all that's important to them. A good way to think of asset inventories is as a shepherd protecting sheep. Having an accurate count of the number of sheep help in a lot of ways. For example, it will be easier to allocate resources, like food, to take care of them. Another benefit of asset inventory might be that you'd get an alert if one of them goes missing.

Once more, think of the important assets you have nearby. Just like me, you're probably able to rate them according to the level of importance. I would rank my wallet ahead of my shoes, for example. In security, this practice is known as asset classification. In general, asset classification is the practice of labeling assets based on the sensitivity and importance to an organization. Organizations label assets differently. Many of them follow a basic classification scheme: public, internal-only, confidential, and restricted.

Public assets can be shared with anyone. Internal-only can be shared with anyone in the organization but should not be shared outside of it. And confidential assets should only be accessed by those working on a specific project. Assets classified as restricted are typically highly sensitive and must be protected. Assets with this label are considered need-to-know. Examples include intellectual property and health or payment information. For example, a growing online retailer might mark internal emails about a new product as confidential because those working on the new product should know about it. They might also label the doors at their offices with the restricted sign to keep everyone out who doesn't have a specific reason to be in there. These are just a couple of everyday examples that you may be familiar with from your prior experience.

Asset management is the process of tracking assets and the risks that affect them. The idea behind this process is simple: you can only protect what you know you have.
Previously, you learned that identifying, tracking, and classifying assets are all important parts of asset management. In this reading, you'll learn more about the purpose and benefits of asset classification, including common classification levels.

Why asset management matters

Keeping assets safe requires a workable system that helps businesses operate smoothly. Setting these systems up requires having detailed knowledge of the assets in an environment. For example, a bank needs to have money available each day to serve its customers. Equipment, devices, and processes need to be in place to ensure that money is available and secure from unauthorized access.
Organizations protect a variety of different assets. Some examples might include:

- Digital assets such as customer data or financial records.
- Information systems that process data, like networks or software.
- Physical assets which can include facilities, equipment, or supplies.
- Intangible assets such as brand reputation or intellectual property.

Regardless of its type, every asset should be classified and accounted for. As you may recall, **asset classification** is the practice of labeling assets based on sensitivity and importance to an organization. Determining each of those two factors varies, but the sensitivity and importance of an asset typically requires knowing the following:

- What you have
- Where it is
- Who owns it, and
- How important it is

An organization that classifies its assets does so based on these characteristics. Doing so helps them determine the sensitivity and value of an asset.

Common asset classifications

Asset classification helps organizations implement an effective risk management strategy. It also helps them prioritize security resources, reduce IT costs, and stay in compliance with legal regulations.

The most common classification scheme is: restricted, confidential, internal-only, and public.

- **Restricted** is the highest level. This category is reserved for incredibly sensitive assets, like need-to-know information.
- **Confidential** refers to assets whose disclosure may lead to a significant negative impact on an organization.
- **Internal-only** describes assets that are available to employees and business partners.
- **Public** is the lowest level of classification. These assets have no negative consequences to the organization if they're released.

How this scheme is applied depends greatly on the characteristics of an asset. It might surprise you to learn that identifying an asset's owner is sometimes the most complicated characteristic to determine.

Note: Although many organizations adopt this classification scheme, there can be variability at the highest levels. For example, government organizations label their most sensitive assets as confidential instead of restricted.

Challenges of classifying information

Identifying the owner of certain assets is straightforward, like the owner of a building. Other types of assets can be trickier to identify. This is especially true when it comes to information.

For example, a business might issue a laptop to one of its employees to allow them to work remotely. You might assume the business is the asset owner in this situation. But, what if the employee uses the laptop for personal matters, like storing their photos?

Ownership is just one characteristic that makes classifying information a challenge. Another concern is that information can have multiple classification values at the same time. For example, consider a letter addressed to you in the mail. The letter contains some public information that's okay to share, like your name. It also contains fairly confidential pieces of information that you'd rather only be available to certain people, like your address. You'll learn more about how these challenges are addressed as you continue through the program.

Digital and physical assets

Assets in a digital world

Security teams classify assets based on value. Next, let's expand our security mindset and think about this question. What exactly is valuable about an asset?

These days, the answer is often information. Most information is in a digital form. We call this data. Data is information that is translated, processed, or stored by a computer. We live in a connected world. Billions of devices around the world are linked to the internet and are exchanging data with each other all the time. In fact, millions of pieces of data are being passed to your device right now! When compared to physical assets, digital assets have additional challenges. What you need to understand is that protecting data depends on where that data is and what it's doing. Security teams protect data in three different states: in use, in transit, and at rest. Let's investigate this idea in greater detail.

Data in use is data being accessed by one or more users. Imagine being at a park with your laptop. It's a nice sunny day, and you stop at a bench to check your email. This is an example of data in use. As soon as you log in, your inbox is considered to be in use.

Next, is data in transit. Data in transit is data traveling from one point to another. While you're signed into your account, a message from one of your friends appears. They sent you an interesting article about the growing security industry. You decide to reply, thanking them for sending this to you. When you click send, this is now an example of data in transit.

Finally, there's data at rest. Data at rest is data not currently being accessed. In this state, data is typically stored on a physical device. An example of data at rest would be when you finish checking your email and close your laptop. You then decide to pack up and go to a nearby cafe for breakfast. As you make your way from the park towards the cafe, the data in your laptop is at rest. So now that we understand these states of data, let's connect this back to asset management.

Earlier, I mentioned that information is one of the most valuable assets that companies can have. Information security, or InfoSec, is the practice of keeping data in all states away from unauthorized users. Weak information security is a serious problem. It can lead to things like identity theft, financial loss, and reputational damage. These events have potential to harm organizations, their partners, and their customers.

And there's more to consider in your work as a security analyst. As our digital world continually changes, we are adapting our understanding of data at rest. Physical devices like our smartphones more commonly store data in the cloud, meaning that our information isn't necessarily at rest just because our phone is resting on a table. We should always be mindful of new vulnerabilities as our world becomes increasingly connected.

Soaring into the cloud

Starting an online business used to be a complicated and costly process. In years past, companies had to build and maintain their own internal solutions to operate in the digital marketplace. Now, it’s much easier for anyone to participate because of the cloud.

The availability of cloud technologies has drastically changed how businesses operate online. These new tools allow companies to scale and adapt quickly while also lowering their costs. Despite these benefits, the shift to cloud-based services has also introduced a range of new cybersecurity challenges that put assets at risk.

Cloud-based services

The term cloud-based services refers to a variety of on demand or web-based business solutions. Depending on a company’s needs and budget, services can range from website hosting, to application development environments, to entire back-end infrastructure.

There are three main categories of cloud-based services:

- Software as a service (SaaS)
- Platform as a service (PaaS)
- Infrastructure as a service (IaaS)

Software as a service (SaaS)

SaaS refers to front-end applications that users access via a web browser. The service providers host, manage, and maintain all of the back-end systems for those applications. Common examples of SaaS services include applications like Gmail™ email service, Slack, and Zoom software.

Platform as a service (PaaS)

PaaS refers to back-end application development tools that clients can access online. Developers use these resources to write code and build, manage, and deploy their own apps. Meanwhile, the cloud service providers host and maintain the back-end hardware and software that the apps use to operate. Some examples of PaaS services include Google App Engine™ platform, Heroku®, and VMware Cloud Foundry.

Infrastructure as a service (IaaS)

IaaS customers are given remote access to a range of back-end systems that are hosted by the cloud service provider. This includes data processing servers, storage, networking resources, and more. Resources are commonly licensed as needed, making it a cost-effective alternative to buying and maintaining on premises.

Cloud-based services allow companies to connect with their customers, employees, and business partners over the internet. Some of the largest organizations in the world offer cloud-based services:

- Google Cloud Platform
- Microsoft Azure

Cloud security

Shifting applications and infrastructure over to the cloud can make it easier to operate an online business. It can also complicate keeping data private and safe. Cloud security is a growing subfield of cybersecurity that specifically focuses on the protection of data, applications, and infrastructure in the cloud.

In a traditional model, organizations had their entire IT infrastructure on premises. Protecting those systems was entirely up to the internal security team in that environment. These responsibilities are not so clearly defined when part or all of an operational environment is in the cloud.

For example, a PaaS client pays to access the resources they need to build their applications. So, it is reasonable to expect them to be responsible for securing the apps they build. On the other hand, the responsibility for maintaining the security of the servers they are accessing should belong to the cloud service provider because there are other clients using the same systems.

In cloud security, this concept is known as the shared responsibility model. Clients are commonly responsible for securing anything that is directly within their control:

- Identity and access management
- Resource configuration
- Data handling

Note: The amount of responsibility that is delegated to a service provider varies depending on the service being used: SaaS, PaaS, and IaaS.

Cloud security challenges

All service providers do their best to deliver secure products to their customers. Much of their success depends on preventing breaches and how well they can protect sensitive information. However, since data is stored in the cloud and accessed over the internet, several challenges arise:

- **Misconfiguration** is one of the biggest concerns. Customers of cloud-based services are responsible for configuring their own security environment. Oftentimes, they use out-of-the-box configurations that fail to address their specific security objectives.
- **Cloud-native breaches** are more likely to occur due to misconfigured services.
- **Monitoring access might be difficult** depending on the client and level of service.
- **Meeting regulatory standards** is also a concern, particularly in industries that are required by law to follow specific requirements such as HIPAA, PCI DSS, and GDPR.

Many other challenges exist besides these. As more businesses adopt cloud-based services, there's a growing need for cloud security professionals to meet a growing number of risks. Burning Glass, a leading labor market analytics firm, ranks cloud security among the most in-demand skills in cybersecurity.

Risk and asset security

Plans come in many shapes and sizes, but they all share a common goal: to be prepared for risks when they happen. Placing the focus on people is what leads to the most effective security plans. Considering the diverse backgrounds and perspectives of everyone involved ensures that no one is left out when something goes wrong. We talked earlier about the risk as being anything that can impact the confidentiality, integrity, or availability of an asset. Most security plans address risks by breaking them down according to categories and factors.

Some common risk categories might include, the damage, disclosure, or loss of information. Any of these can be due to factors like the physical damage or malfunctions of a device. There are also factors like attacks and human error. For example, a new school teacher may be asked to sign a contract before their first day of class. The agreement may warn against some common risks associated with human error, like using a personal email to send sensitive information. A security plan may require that all new hires sign off on this agreement, effectively spreading the values that ensure everyone's in alignment. This is just one example of the types and causes of risk that a plan might address. These things vary widely depending on the company. But how these plans are communicated is similar across industries.

Security plans consist of three basic elements: policies, standards, and procedures. These three elements are how companies share their security plans. These words tend to be used interchangeably outside of security, but you'll soon discover that they each have a very specific meaning and function in this context.

A policy in security is a set of rules that reduce risk and protects information. Policies are the foundation of every security plan. They give everyone in and out of an organization guidance by addressing questions like, what are we protecting and why? Policies focus on the strategic side of things by identifying the scope, objectives, and limitations of a security plan. For instance, newly hired employees at many companies are required to sign off on acceptable use policy, or AUP. These provisions outline secure ways that an employee may access corporate systems.

Standards are the next part. These have a tactical function, as they concern how well we're protecting assets. In security, standards are references that inform how to set policies. A good way to think of standards is that they create a point of reference. For example, many companies use the password management standard identified in NIST Special Publication 800-63B to improve their security policies by specifying that employees' passwords must be at least eight characters long.

The last part of a plan is its procedures. Procedures are step-by-step instructions to perform a specific security task. Organizations usually keep multiple procedure documents that are used throughout the company, like how employees can choose secure passwords, or how they can securely reset a password if it's been locked. Sharing clear and actionable procedures with everyone creates accountability, consistency, and efficiency across an organization.

Policies, standards, and procedures vary widely from one company to another because they are tailored to each organization's goals.

The NIST Cybersecurity Framework

Compliance is the process of adhering to internal standards and external regulations. Small companies and large organizations around the world place security compliance at the top of their list of priorities. At a high-level, maintaining trust, reputation, safety, and the integrity of your data are just a few reasons to be concerned about compliance. Fines, penalties, and lawsuits are other reasons. This is particularly true for companies in highly regulated industries, like health care, energy, and finance. Being out of compliance with a regulation can cause long lasting financial and reputational effects that can seriously impact a business.

Regulations are rules set by a government or other authority to control the way something is done. Like policies, regulations exist to protect people and their information, but on a larger scale. Compliance can be a complex process because of the many regulations that exist all around the world. For our purpose, we're going to focus on a framework of security compliance, the U.S. based NIST Cybersecurity Framework.

Earlier in the program, you learned the National Institute of Standards and Technology, or NIST. One of the primary roles of NIST is to openly provide companies with a set of frameworks and security standards that reflect key security related regulations. The NIST Cybersecurity Framework is a voluntary framework that consists of standards, guidelines, and best practices to manage cybersecurity risk. Commonly known as the CSF, this framework was developed to help businesses secure one of their most important assets, information. The CSF consists of three main components: the core, it's tiers, and it's profiles. Let's explore each of these together to build a better understanding of how NIST's CSF is used.

The core is basically a simplified version of the functions, or duties, of a security plan. The CSF core identifies five broad functions: identify, protect, detect, respond, and recover. Think of these categories of the core as a security checklist.

After the core, the next NIST component we'll discuss is its tiers. These provide security teams with a way to measure performance across each of the five functions of the core. Tiers range from Level-1 to Level-4. Level-1, or passive, indicates a function is reaching bare minimum standards. Level-4, or adaptive, is an indication that a function is being performed at an exemplary standard. You may have noticed that CSF tiers aren't a yes or no proposition; instead, there's a range of values. That's because tiers are designed as a way of showing organizations what is and isn't working with their security plans.

Lastly, profiles are the final component of CSF. These provide insight into the current state of a security plan. One way to think of profiles is like photos capturing a moment in time. Comparing photos of the same subject taken at different times can provide useful insights. For example, without these photos, you might not notice how this tree has changed. It's the same with NIST profiles.

RECOVER
IDENTIFY
RESPO
OTECT

Origins of the framework

Originally released in 2014, NIST developed the Cybersecurity Framework to protect critical infrastructure in the United States. NIST was selected to develop the CSF because they are an unbiased source of scientific data and practices. NIST eventually adapted the CSF to fit the needs of businesses in the public and private sector. Their goal was to make the framework more flexible, making it easier to adopt for small businesses or anyone else that might lack the resources to develop their own security plans.

Components of the CSF

As you might recall, the framework consists of three main components: the *core*, *tiers*, and *profiles*. In the following sections, you'll learn more about each of these CSF components.

Core

The CSF core is a set of desired cybersecurity outcomes that help organizations customize their security plan. It consists of five functions, or parts: Identify, Protect, Detect, Respond, and Recover. These functions are commonly used as an informative reference to help organizations *identify* their most important assets and *protect* those assets with appropriate safeguards. The CSF core is also used to understand ways to *detect* attacks and develop *response* and *recovery* plans should an attack happen.

Tiers

The CSF tiers are a way of measuring the sophistication of an organization's cybersecurity program. CSF tiers are measured on a scale of 1 to 4. Tier 1 is the lowest score, indicating that a limited set of security controls have been implemented. Overall, CSF tiers are used to assess an organization's security posture and identify areas for improvement.

Profiles

The CSF profiles are pre-made templates of the NIST CSF that are developed by a team of industry experts. CSF profiles are tailored to address the specific risks of an organization or industry. They are used to help organizations develop a baseline for their cybersecurity plans, or as a way of comparing their current cybersecurity posture to a specific industry standard.

Note: The core, tiers, and profiles were each designed to help any business improve their security operations. Although there are only three components, the entire framework consists of a complex system of subcategories and processes.

Implementing the CSF

As you might recall, compliance is an important concept in security. **Compliance** is the process of adhering to internal standards and external regulations. In other words, compliance is a way of measuring how well an organization is protecting their assets. The **NIST Cybersecurity Framework (CSF)** is a voluntary framework that consists of standards, guidelines, and best practices to manage cybersecurity risk. Organizations may choose to use the CSF to achieve compliance with a variety of regulations.

Note: Regulations are rules that *must* be followed, while frameworks are resources you can *choose* to use.

Since its creation, many businesses have used the NIST CSF. However, CSF can be a challenge to implement due to its high level of detail. It can also be tough to find where the framework fits in. For example, some businesses have established security plans, making it unclear how CSF can benefit them. Alternatively, some businesses might be in the early stages of building their plans and need a place to start.

In any scenario, the U.S. Cybersecurity and Infrastructure Security Agency (CISA) provides detailed guidance that any organization can use to implement the CSF. This is a quick overview and summary of their recommendations:

- **Create a current profile** of the security operations and outline the specific needs of your business.
- **Perform a risk assessment** to identify which of your current operations are meeting business and regulatory standards.
- **Analyze and prioritize existing gaps** in security operations that place the businesses assets at risk.
- **Implement a plan of action** to achieve your organization's goals and objectives.

Pro tip: Always consider current risk, threat, and vulnerability trends when using the NIST CSF.
You can learn more about implementing the CSF in this report by CISA that outlines how the framework was applied in the commercial facilities sector.

Industries embracing the CSF

The NIST CSF has continued to evolve since its introduction in 2014. Its design is influenced by the standards and best practices of some of the largest companies in the world.
A benefit of the framework is that it aligns with the security practices of many organizations across the global economy. It also helps with regulatory compliance that might be shared by business partners.

Terms and definitions from Course 5, Module 1

- **Asset:** An item perceived as having value to an organization
- **Asset classification:** The practice of labeling assets based on sensitivity and importance to an organization
- **Asset inventory:** A catalog of assets that need to be protected
- **Asset management:** The process of tracking assets and the risks that affect them
- **Compliance:** The process of adhering to internal standards and external regulations
- **Data:** Information that is translated, processed, or stored by a computer
- **Data at rest:** Data not currently being accessed
- **Data in transit:** Data traveling from one point to another
- **Data in use:** Data being accessed by one or more users
- **Information security (InfoSec):** The practice of keeping data in all states away from unauthorized users
- **National Institute of Standards and Technology (NIST) Cybersecurity Framework (CSF):** A voluntary framework that consists of standards, guidelines, and best practices to manage cybersecurity risk
- **Policy:** A set of rules that reduce risk and protect information
- **Procedures:** Step-by-step instructions to perform a specific security task
- **Regulations:** Rules set by a government or other authority to control the way something is done
- **Risk**: Anything that can impact confidentiality, integrity, or availability of an asset
- **Standards:** References that inform how to set policies
- **Threat:** Any circumstance or event that can negatively impact assets

- **Vulnerability:** A weakness that can be exploited by a threat

Module 2 - Protect organizational assets

The **principle of least privilege** is a security concept in which a user is only granted the minimum level of access and authorization required to complete a task or function.
Least privilege is a fundamental security control that supports the confidentiality, integrity, and availability (CIA) triad of information. In this reading, you'll learn how the principle of least privilege reduces risk, how it's commonly implemented, and why it should be routinely audited.

Limiting access reduces risk

Every business needs to plan for the risk of data theft, misuse, or abuse. Implementing the principle of least privilege can greatly reduce the risk of costly incidents like data breaches by:

- Limiting access to sensitive information
- Reducing the chances of accidental data modification, tampering, or loss
- Supporting system monitoring and administration

Least privilege greatly reduces the likelihood of a successful attack by connecting specific resources to specific users and placing limits on what they can do. It's an important security control that should be applied to any asset. Clearly defining who or what your users are is usually the first step of implementing least privilege effectively.
Note: Least privilege is closely related to another fundamental security principle, the *separation of duties*—a security concept that divides tasks and responsibilities among different users to prevent giving a single user complete control over critical business functions. You'll learn more about separation of duties in a different reading about identity and access management.

Determining access and authorization

To implement least privilege, access and authorization must be determined first. There are two questions to ask to do so:

- Who is the user?
- How much access do they need to a specific resource?

Determining who the user is usually straightforward. A user can refer to a person, like a customer, an employee, or a vendor. It can also refer to a device or software that's connected to your business network. In general, every user should have their own account. Accounts are typically stored and managed within an organization's directory service.
These are the most common types of user accounts:

- **Guest accounts** are provided to external users who need to access an internal network, like customers, clients, contractors, or business partners.
- **User accounts** are assigned to staff based on their job duties.
- **Service accounts** are granted to applications or software that needs to interact with other software on the network.
- **Privileged accounts** have elevated permissions or administrative access.

It's best practice to determine a baseline access level for each account type before implementing least privilege. However, the appropriate access level can change from one moment to the next. For example, a customer support representative should only have access to your information while they are helping you. Your data should then become inaccessible when the support agent starts working with another customer and they are no longer actively assisting you. Least privilege can only reduce risk if user accounts are routinely and consistently monitored.

Pro tip: Passwords play an important role when implementing the principle of least privilege. Even if user accounts are assigned appropriately, an insecure password can compromise your systems.

Auditing account privileges

Setting up the right user accounts and assigning them the appropriate privileges is a helpful first step. Periodically auditing those accounts is a key part of keeping your company's systems secure.

There are three common approaches to auditing user accounts:

- Usage audits
- Privilege audits
- Account change audits

As a security professional, you might be involved with any of these processes.

Usage audits

When conducting a usage audit, the security team will review which resources each account is accessing and what the user is doing with the resource. Usage audits can help determine whether users are acting in accordance with an organization's security policies. They can also help identify whether a user has permissions that can be revoked because they are no longer being used.

Privilege audits

Users tend to accumulate more access privileges than they need over time, an issue known as *privilege creep*. This might occur if an employee receives a promotion or switches teams and their job duties change. Privilege audits assess whether a user's role is in alignment with the resources they have access to.

Account change audits

Account directory services keep records and logs associated with each user. Changes to an account are usually saved and can be used to audit the directory for suspicious activity, like multiple attempts to change an account password. Performing account change audits helps to ensure that all account changes are made by authorized users.

Note: Most directory services can be configured to alert system administrators of suspicious activity.

Organizations of all sizes handle a large amount of data that must be kept private. You learned that data can be vulnerable whether it is at rest, in use, or in transit. Regardless of the state it is in, information should be kept private by limiting access and authorization.

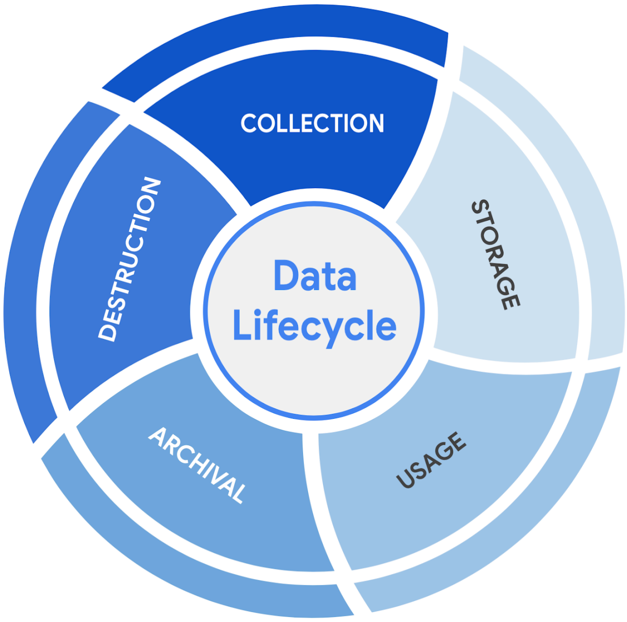
In security, data vulnerabilities are often mapped in a model known as the data lifecycle. Each stage of the data lifecycle plays an important role in the security controls that are put in place to maintain the CIA triad of information. In this reading, you will learn about the data lifecycle, the plans that determine how data is protected, and the specific types of data that require extra attention.

The data lifecycle

The data lifecycle is an important model that security teams consider when protecting information. It influences how they set policies that align with business objectives. It also plays an important role in the technologies security teams use to make information accessible.

In general, the data lifecycle has five stages. Each describe how data flows through an organization from the moment it is created until it is no longer useful:

- Collect
- Store
- Use
- Archive
- Destroy



Protecting information at each stage of this process describes the need to keep it accessible and recoverable should something go wrong.

Data governance

Businesses handle massive amounts of data every day. New information is constantly being collected from internal and external sources. A structured approach to managing all of this data is the best way to keep it private and secure.

Data governance is a set of processes that define how an organization manages information. Governance often includes policies that specify how to keep data private, accurate, available, and secure throughout its lifecycle.

Effective data governance is a collaborative activity that relies on people. Data governance policies commonly categorize individuals into a specific role:

- **Data owner:** the person that decides who can access, edit, use, or destroy their information.
- **Data custodian**: anyone or anything that's responsible for the safe handling, transport, and storage of information.
- **Data steward**: the person or group that maintains and implements data governance policies set by an organization.

Businesses store, move, and transform data using a wide range of IT systems. Data governance policies often assign accountability to data owners, custodians, and stewards.

Note: As a data custodian, you will primarily be responsible for maintaining security and privacy rules for your organization.

Protecting data at every stage

Most security plans include a specific policy that outlines how information will be managed across an organization. This is known as a data governance policy. These documents clearly define procedures that should be followed to participate in keeping data safe. They place limits on who or what can access data. Security professionals are important participants in data governance. As a data custodian, you will be responsible for ensuring that data isn't damaged, stolen, or misused.

Legally protected information

Data is more than just a bunch of 1s and 0s being processed by a computer. Data can represent someone's personal thoughts, actions, and choices. It can represent a purchase, a sensitive medical decision, and everything in between. For this reason, data owners should be the ones deciding whether or not to share their data. As a security professional, protecting a person's data privacy decisions must always be respected.

Securing data can be challenging. In large part, that's because data owners generate more data than they can manage. As a result, data custodians and stewards sometimes lack direct, explicit instructions on how they should handle specific types of data. Governments and other regulatory agencies have bridged this gap by creating rules that specify the types of information that organizations must protect by default:

- **PII** is any information used to infer an individual's identity. Personally identifiable information, or PII, refers to information that can be used to contact or locate someone.
- **PHI** stands for protected health information. In the U.S., it is regulated by the Health Insurance Portability and Accountability Act (HIPAA), which defines PHI as “information that relates to the past, present, or future physical or mental health or condition of an individual.” In the EU, PHI has a similar definition but it is regulated by the General Data Protection Regulation (GDPR).
- **SPII** is a specific type of PII that falls under stricter handling guidelines. The *S* stands for sensitive, meaning this is a type of personally identifiable information that should only be accessed on a need-to-know basis, such as a bank account number or login credentials.

Overall, it's important to protect all types of personal information from unauthorized use and disclosure.

Information security vs. information privacy

Security and privacy are two terms that often get used interchangeably outside of this field. Although the two concepts are connected, they represent specific functions:

- **Information privacy** refers to the protection of unauthorized access and distribution of data
- **Information security** (InfoSec) refers to the practice of keeping data in all states away from unauthorized users.

The key difference: Privacy is about providing people with control over their personal information and how it's shared. Security is about protecting people’s choices and keeping their information safe from potential threats.

For example, a retail company might want to collect specific kinds of personal information about its customers for marketing purposes, like their age, gender, and location. How this private information will be used should be disclosed to customers before it's collected. In addition, customers should be given an option to opt-out if they decide not to share their data. Once the company obtains consent to collect personal information, it might implement specific security controls in place to protect that private data from unauthorized access, use, or disclosure. The company should also have security controls in place to respect the privacy of all stakeholders and anyone who chose to opt-out.

Note: Privacy and security are both essential for maintaining customer trust and brand reputation.

Why privacy matters in security

Data privacy and protection are topics that started gaining a lot of attention in the late 1990s. At that time, tech companies suddenly went from processing people’s data to storing and using it for business purposes. For example, if a user searched for a product online, companies began storing and sharing access to information about that user’s search history with other companies. Businesses were then able to deliver personalized shopping experiences to the user for free.

Eventually this practice led to a global conversation about whether these organizations had the right to collect and share someone’s private data. Additionally, the issue of data security became a greater concern; the more organizations collected data, the more vulnerable it was to being abused, misused, or stolen.

Many organizations became more concerned about the issues of data privacy. Businesses became more transparent about how they were collecting, storing, and using information. They also began implementing more security measures to protect people's data privacy. However, without clear rules in place, protections were inconsistently applied.

Note: The more data is collected, stored, and used, the more vulnerable it is to breaches and threats.

Notable privacy regulations

Businesses are required to abide by certain laws to operate. As you might recall, **regulations** are rules set by a government or another authority to control the way something is done. Privacy regulations in particular exist to protect a user from having their information collected, used, or shared without their consent. Regulations may also describe the security measures that need to be in place to keep private information away from threats.

Three of the most influential industry regulations that every security professional should know about are:

- General Data Protection Regulation (GDPR)
- Payment Card Industry Data Security Standard (PCI DSS)
- Health Insurance Portability and Accountability Act (HIPAA)

GDPR

GDPR is a set of rules and regulations developed by the European Union (EU) that puts data owners in total control of their personal information. Under GDPR, types of personal information include a person's name, address, phone number, financial information, and medical information.

The GDPR applies to any business that handles the data of EU citizens or residents, regardless of where that business operates. For example, a US based company that handles the data of EU visitors to their website is subject to the GDPRs provisions.

PCI DSS

PCI DSS is a set of security standards formed by major organizations in the financial industry. This regulation aims to secure credit and debit card transactions against data theft and fraud.

HIPAA

HIPAA is a U.S. law that requires the protection of sensitive patient health information. HIPAA prohibits the disclosure of a person's medical information without their knowledge and consent.

Note: These regulations influence data handling at many organizations around the world even though they were developed by specific nations.

Several other security and privacy compliance laws exist. Which ones your organization needs to follow will depend on the industry and the area of authority. Regardless of the circumstances, regulatory compliance is important to every business.

Security assessments and audits

Businesses should comply with important regulations in their industry. Doing so validates that they have met a minimum level of security while also demonstrating their dedication to maintaining data privacy.

Meeting compliance standards is usually a continual, two-part process of security audits and assessments:

- A **security audit** is a review of an organization's security controls, policies, and procedures against a set of expectations.
- A **security assessment** is a check to determine how resilient current security implementations are against threats.

For example, if a regulation states that multi-factor authentication (MFA) must be enabled for all administrator accounts, an audit might be conducted to check those user accounts for compliance. After the audit, the internal team might perform a security assessment that determines many users are using weak passwords. Based on their assessment, the team could decide to enable MFA on all user accounts to improve their overall security posture.

Note: Compliance with legal regulations, such as GDPR, can be determined during audits.

As a security analyst, you are likely to be involved with security audits and assessments in the field. Businesses usually perform security audits less frequently, approximately once per year. Security audits may be performed both internally and externally by different third-party groups.

In contrast, security assessments are usually performed more frequently, about every three-to-six months. Security assessments are typically performed by internal employees, often as preparation for a security audit. Both evaluations are incredibly important ways to ensure that your systems are effectively protecting everyone's privacy.

Encryption methods

Fundamentals of cryptography

Maintaining the privacy of PII online is difficult. It takes the right security controls to do so. One of the main security controls used to protect information online is cryptography. Cryptography is the process of transforming information into a form that unintended readers can't understand. Data of any kind is kept secret using a two-step process: encryption to hide the information, and decryption to unhide it.

Imagine sending an email to a friend. The process starts by taking data in its original and readable form, known as plaintext. Encryption takes that information and scrambles it into an unreadable form, known as ciphertext. We then use decryption to unscramble the ciphertext back into plaintext form, making it readable again.

Hiding and unhiding private information is a practice that's been around for a long time. Way before computers! One of the earliest cryptographic methods is known as Caesar's cipher. This method is named after a Roman general, Julius Caesar, who ruled the Roman empire near the end of the first century BC. He used it to keep messages between him and his military generals private.

Caesar's cipher is a pretty simple algorithm that works by shifting letters in the Roman alphabet forward by a fixed number of spaces. An algorithm is a set of rules that solve a problem. Specifically in cryptography, a cipher is an algorithm that encrypts information.

For example, a message encoded with Caesar's cipher using a shift of 3 would encode an A as a D, a B as an E, a C as an F, and so on. In this example, you could send a friend a message that said, "hello" using a shift of 3, and it would read "khoor." Now, you might be wondering how would you know the shift a message encrypted with Caesar's cipher is using. The answer to that is, you need the key!

A cryptographic key is a mechanism that decrypts ciphertext. In our example, the key would tell you that my message is encrypted by 3 shifts. With that information, you can unlock the hidden message!

Every form of encryption relies on both a cipher and key to secure the exchange of information. Caesar's cipher is not widely used today because of a couple of major flaws. One concerns the cipher itself. The other relates to the key. This particular cipher relies entirely on the characters of the Roman alphabet to hide information. For example, consider a message written using the English alphabet, which is only 26 characters. Even without the key, it's pretty simple to crack a message secured with Caesar's cipher by shifting letters 26 different ways.

In information security, this tactic is known as brute force attack, a trial-and-error process of discovering private information.

The other major flaw of Caesar's cipher is that it relies on a single key. If that key was lost or stolen, there's nothing stopping someone from accessing private information. Properly keeping track of cryptographic keys is an important part of security. To start, it's important to ensure that these keys are not stored in public places, and to share them separately from the information they will decrypt.

Caesar's cipher is just one of many algorithms used to protect people's privacy.

Public key infrastructure

Public key infrastructure, or PKI, is an encryption framework that secures the exchange of information online. It's a broad system that makes accessing information fast, easy, and secure. So, how does it all work?

PKI is a two-step process. It all starts with the exchange of encrypted information. This involves either asymmetric encryption, symmetric encryption, or both.

Asymmetric encryption involves the use of a public and private key pair for encryption and decryption of data. Let's imagine this as a box that can be opened with two keys. One key, the public key, can only be used to access the slot and add items to the box. Since the public key can't be used to remove items, it can be copied and shared with people all around the world to add items. On the other hand, the second key, the private key, opens the box fully, so that the items inside can be removed. Only the owner of the box has access to the private key that unlocks it.

Using a public key allows the people and servers you're communicating with to see and send you encrypted information that only you can decrypt with your private key. This two-key system makes asymmetric encryption a secure way to exchange information online; however, it also slows down the process.

Symmetric encryption, on the other hand, is a faster and simpler approach to key management. Symmetric encryption involves the use of a single secret key to exchange information.

Let's imagine the locked box again. Instead of two keys, symmetric encryption uses the same key. The owner can use it to open the box, add items, and close it again. When they want to share access, they can give the secret key to anyone else to do the same. Exchanging a single secret key may make web communications faster, but it also makes it less secure.

PKI uses both asymmetric and symmetric encryption, sometimes in conjunction with one another. It all depends on whether speed or security is the priority. For example, mobile chat applications use asymmetric encryption to establish a connection between people at the start of a conversation when security is the priority. Afterwards, when the speed of communications back-and-forth is the priority, symmetric encryption takes over.

While both have their own strengths and weaknesses, they share a common vulnerability, establishing trust between the sender and receiver. Both processes rely on sharing keys that can be misused, lost, or stolen. This isn't a problem when we exchange information in person because we can use our senses to tell the difference between those we trust and those we don't trust. Computers, on the other hand, aren't naturally equipped to make this distinction. That's where the second step of PKI applies. PKI addresses the vulnerability of key sharing by establishing trust using a system of digital certificates between computers and networks.

A digital certificate is a file that verifies the identity of a public key holder. Most online information is exchanged using digital certificates. Users, companies, and networks hold one and exchange them when communicating information online as a way of signaling trust. Let's look at an example of how digital certificates are created.

Let's say an online business is about to launch their website, and they want to obtain a digital certificate. When they register their domain, the hosting company sends certain information over to a trusted certificate authority, or CA. The information provided is usually basic things like the company name and the country where its headquarters are located. A public key for the site is also provided. The certificate authority then uses this data to verify the company's identity. When it's confirmed, the CA encrypts the data with its own private key. Finally, they create a digital certificate that contains the encrypted company data. It also contains CA's digital signature to prove that it's authentic.

Digital certificates are a lot like a digital ID badge that's used online to restrict or grant access to information. This is how PKI solves the trust issue. Combined with asymmetric and symmetric encryption, this two-step approach to exchanging secure information between trusted sources is what makes PKI such a useful security control.

Types of encryption

There are two main types of encryption:

- **Symmetric encryption** is the use of a single secret key to exchange information. Because it uses one key for encryption and decryption, the sender and receiver must know the secret key to lock or unlock the cipher.
- **Asymmetric encryption** is the use of a public and private key pair for encryption and decryption of data. It uses two separate keys: a public key and a private key. The public key is used to encrypt data, and the private key decrypts it. The private key is only given to users with authorized access.

The importance of key length

Ciphers are vulnerable to **brute force attacks**, which use a trial and error process to discover private information. This tactic is the digital equivalent of trying every number in a combination lock trying to find the right one. In modern encryption, longer key lengths are considered to be more secure. Longer key lengths mean more possibilities that an attacker needs to try to unlock a cipher.

One drawback to having long encryption keys is slower processing times. Although short key lengths are generally less secure, they’re much faster to compute. Providing fast data communication online while keeping information safe is a delicate balancing act.

Approved algorithms

Many web applications use a combination of symmetric and asymmetric encryption. This is how they balance user experience with safeguarding information. As an analyst, you should be aware of the most widely-used algorithms.

Symmetric algorithms

- *Triple DES (3DES)* is known as a block cipher because of the way it converts plaintext into ciphertext in “blocks.” Its origins trace back to the Data Encryption Standard (DES), which was developed in the early 1970s. DES was one of the earliest symmetric encryption algorithms that generated 64-bit keys. A **bit** is the smallest unit of data measurement on a computer. As you might imagine, Triple DES generates keys that are 192 bits, or three times as long. Despite the longer keys, many organizations are moving away from using Triple DES due to limitations on the amount of data that can be encrypted. However, Triple DES is likely to remain in use for backwards compatibility purposes.

- *Advanced Encryption Standard (AES)* is one of the most secure symmetric algorithms today. AES generates keys that are 128, 192, or 256 bits. Cryptographic keys of this size are considered to be safe from brute force attacks. It's estimated that brute forcing an AES 128-bit key could take a modern computer billions of years!

Asymmetric algorithms

- *Rivest Shamir Adleman (RSA)* is named after its three creators who developed it while at the Massachusetts Institute of Technology (MIT). RSA is one of the first asymmetric encryption algorithms that produces a public and private key pair. Asymmetric algorithms like RSA produce even longer key lengths. In part, this is due to the fact that these functions are creating two keys. RSA key sizes are 1,024, 2,048, or 4,096 bits. RSA is mainly used to protect highly sensitive data.
- *Digital Signature Algorithm (DSA)* is a standard asymmetric algorithm that was introduced by NIST in the early 1990s. DSA also generates key lengths of 2,048 bits. This algorithm is widely used today as a complement to RSA in public key infrastructure.

Generating keys

These algorithms must be implemented when an organization chooses one to protect their data. One way this is done is using OpenSSL, which is an open-source command line tool that can be used to generate public and private keys. OpenSSL is commonly used by computers to verify digital certificates that are exchanged as part of public key infrastructure.

Note: OpenSSL is just one option. There are various others available that can generate keys with any of these common algorithms.

In early 2014, OpenSSL disclosed a vulnerability, known as the Heartbleed bug, that exposed sensitive data in the memory of websites and applications. Although unpatched versions of OpenSSL are still available, the Heartbleed bug was patched later that year (2014). Many businesses today use the secure versions of OpenSSL to generate public and private keys, demonstrating the importance of using up-to-date software.

Obscurity is not security

In the world of cryptography, a cipher must be proven to be unbreakable before claiming that it is secure. According to Kerchoff's principle, cryptography should be designed in such a way that all the details of an algorithm—except for the private key—should be knowable without sacrificing its security. For example, you can access all the details about how AES encryption works online and yet it is still unbreakable.

Occasionally, organizations implement their own, custom encryption algorithms. There have been instances where those secret cryptographic systems have been quickly cracked after being made public.

Pro tip: A cryptographic system *should not* be considered secure if it requires secrecy around how it works.

Encryption is everywhere

Companies use both symmetric and asymmetric encryption. They often work as a team, balancing security with user experience.

For example, websites tend to use asymmetric encryption to secure small blocks of data that are important. Usernames and passwords are often secured with asymmetric encryption while processing login requests. Once a user gains access, the rest of their web session often switches to using symmetric encryption for its speed.

Using data encryption like this is increasingly required by law. Regulations like the Federal Information Processing Standards (FIPS 140-3) and the General Data Protection Regulation (GDPR) outline how data should be collected, used, and handled. Achieving compliance with either regulation is critical to demonstrating to business partners and governments that customer data is handled responsibly.

Non-repudiation and hashing

Encryption keys are vulnerable to being lost or stolen, which can lead to sensitive information at risk. Let's explore another security control that helps companies address this weakness.

A hash function is an algorithm that produces a code that can't be decrypted. Unlike asymmetric and symmetric algorithms, hash functions are one-way processes that do not generate decryption keys. Instead, these algorithms produce a unique identifier known as a hash value, or digest. Here's an example to demonstrate this.

Imagine a company has an internal application that is used by employees and is stored in a shared drive. After passing through a hashing function, the program receives its hash value. For example purposes, we created this relatively short hash value with the MD5 hashing function. Generally, standard hash functions that produce longer hashes are preferred for being more secure.

Next, let's imagine an attacker replaces the program with a modified version that performs malicious actions. The malicious program may work like the original. However, if so much as one line of code is different from the original, it will produce a different hash value. By comparing the hash values, we can validate that the programs are different. Attackers use tricks like this often because they're easily overlooked. Fortunately, hash values help us identify when something like this is happening.

In security, hashes are primarily used as a way to determine the integrity of files and applications.

Data integrity relates to the accuracy and consistency of information. This is known as non-repudiation, the concept that authenticity of information can't be denied.

Hash functions are important security controls that make proven data integrity possible. Analysts use them frequently. One way to do this is by finding the hash value of files or applications and comparing them against known malicious files.

For example, we can use the Linux command line to generate the hash value for any file on your computer. We just launch a shell and type the name of the hashing algorithm we want to use. In this case, we're using a common one known as sha256. Next, we need to enter the file name of any file we want to hash. Let's hash the contents of newfile.txt. Now, we'll press Enter. The terminal generates this unique hash value for the file.

These tools can be compared with the hash values of known online viruses. One such database is VirusTotal. This is a popular tool among security practitioners that's useful for analyzing suspicious files, domains, IPs, and URLs.

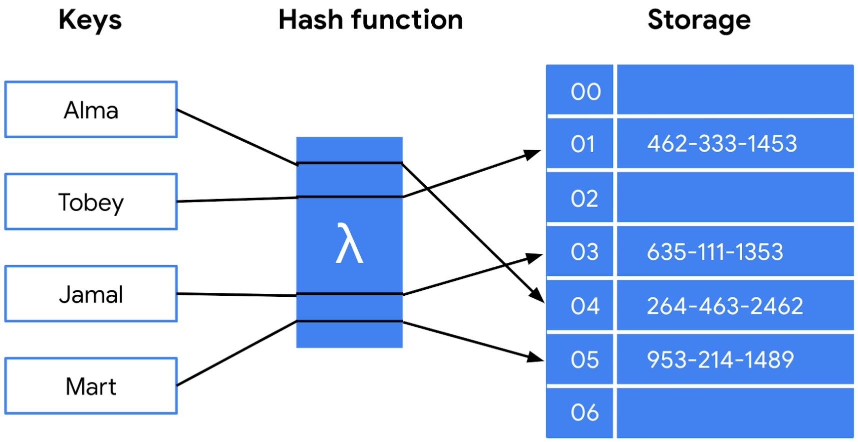
Origins of hashing

Hash functions have been around since the early days of computing. They were originally created as a way to quickly search for data. Since the beginning, these algorithms have been designed to represent data of any size as small, fixed-size values, or digests. Using a hash table, which is a data structure that's used to store and reference hash values, these small values became a more secure and efficient way for computers to reference data.

One of the earliest hash functions is Message Digest 5, more commonly known as MD5. Professor Ronald Rivest of the Massachusetts Institute of Technology (MIT) developed MD5 in the early 1990s as a way to verify that a file sent over a network matched its source file. Whether it's used to convert a single email or the source code of an application, MD5 works by converting data into a 128-bit value. You might recall that a **bit** is the smallest unit of data measurement on a computer. Bits can either be a 0 or 1. In a computer, bits represent user input in a way that computers can interpret. In a hash table, this appears as a string of 32 characters. Altering anything in the source file generates an entirely new hash value.

Generally, the longer the hash value, the more secure it is. It wasn't long after MD5's creation that security practitioners discovered 128-bit digests resulted in a major vulnerability.

Here is an example of how plaintext gets turned into hash values:



Hash collisions

One of the flaws in MD5 happens to be a characteristic of all hash functions. Hash algorithms map any input, regardless of its length, into a fixed-size value of letters and numbers. What's the problem with that? Although there are an infinite amount of possible inputs, there's only a finite set of available outputs!

MD5 values are limited to 32 characters in length. Due to the limited output size, the algorithm is considered to be vulnerable to **hash collision**, an instance when different inputs produce the same hash value. Because hashes are used for authentication, a hash collision is similar to copying someone's identity. Attackers can carry out collision attacks to fraudulently impersonate authentic data.

Next-generation hashing

To avoid the risk of hash collisions, functions that generated longer values were needed. MD5's shortcomings gave way to a new group of functions known as the Secure Hashing Algorithms, or SHAs.

The National Institute of Standards and Technology (NIST) approves each of these algorithms. Numbers besides each SHA function indicate the size of its hash value in bits. Except for SHA-1, which produces a 160-bit digest, these algorithms are considered to be collision-resistant. However, that doesn't make them invulnerable to other exploits.

Five functions make up the SHA family of algorithms:

- SHA-1
- SHA-224
- SHA-256
- SHA-384
- SHA-512

Secure password storage

Passwords are typically stored in a database where they are mapped to a username. The server receives a request for authentication that contains the credentials supplied by the user. It then looks up the username in the database and compares it with the password that was provided and verifies that it matches before granting them access.
This is a safe system unless an attacker gains access to the user database. If passwords are stored in plaintext, then an attacker can steal that information and use it to access company resources. Hashing adds an additional layer of security. Because hash values can't be reversed, an attacker would not be able to steal someone's login credentials if they managed to gain access to the database.

Rainbow tables

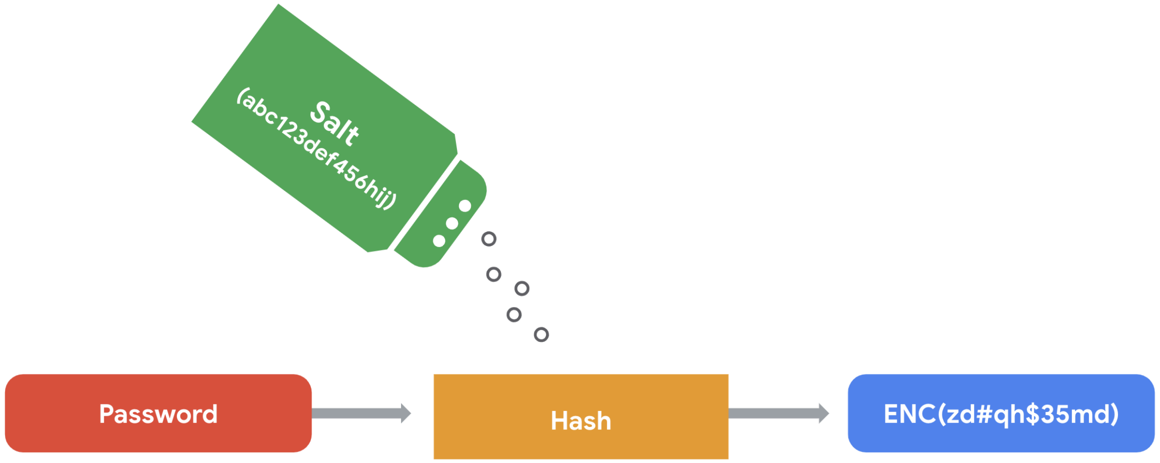
A **rainbow table** is a file of pre-generated hash values and their associated plaintext. They're like dictionaries of weak passwords. Attackers capable of obtaining an organization's password database can use a rainbow table to compare them against all possible values.

Adding some “salt”

Functions with larger digests are less vulnerable to collision and rainbow table attacks. But as you’re learning, no security control is perfect.

Salting is an additional safeguard that's used to strengthen hash functions. A *salt* is a random string of characters that's added to data before it's hashed. The additional characters produce a more unique hash value, making salted data resilient to rainbow table attacks.

For example, a database containing passwords might have several hashed entries for the password "password." If those passwords were all salted, each entry would be completely different. That means an attacker using a rainbow table would be unable to find matching values for "password" in the database.



For this reason, salting has become increasingly common when storing passwords and other types of sensitive data. The length and uniqueness of a salt is important. Similar to hash values, the longer and more complex a salt is, the harder it is to crack.

Authentication, authorization, and accounting

Protecting data is a fundamental feature of security controls. When it comes to keeping information safe and secure, hashing and encryption are powerful, yet limited tools. Managing who or what has access to information is also key to safeguarding information.

The next series of controls that we'll be exploring are access controls, the security controls that manage access, authorization, and accountability of information. When done well, access controls maintain data confidentiality, integrity, and availability. They also get users the information they need quickly.

These systems are commonly broken down into three separate, yet related functions known as the authentication, authorization, and accounting framework. Each control has its own protocol and systems that make them work. In this video, let's get comfortable with the basics of the first one on the list, authentication.

Authentication systems are access controls that serve a very basic purpose. They ask anything attempting to access information this simple question: who are you? Organizations go about collecting answers to these questions differently, depending on the objectives of their security policy. Some are more thorough than others, but in general, responses to this question can be based on three factors of authentication.

The first is knowledge. Authentication by knowledge refers to something the user knows, like a password or the answer to a security question they provided previously.

Another factor is ownership, referring to something the user possesses. A commonly used type of authentication by ownership is a one-time passcode, or OTP. You've probably experienced these at one time or another. They're a random number sequence that an application or website will send you via text or email and ask you to provide.

Last is characteristic. Authentication by this factor is something the user is. Biometrics, like fingerprint scans on your smartphone, are example of this type of authentication. While not used everywhere, this form of authentication is becoming more common because it's much tougher for criminals to impersonate someone if they have to mimic a fingerprint or facial scan as opposed to a password.

The information provided during authentication needs to match the information on file for these access controls to work. When the credentials don't match, authentication fails and access is denied. When they match, access is granted.

Incorrectly denying access can be frustrating to anyone. To make access systems more convenient, many organizations these days rely on single sign-on. Single sign-on, or SSO, is a technology that combines several different logins into one. Can you imagine having to reintroduce yourself every time you meet up with a friend? That's exactly the sort of problem SSO solves.

Instead of requiring users to authenticate over and over again, SSO establishes their identity once, allowing them to gain access to company resources faster. While SSO systems are helpful when it comes to speeding up the authentication process, they present a significant vulnerability when used alone.

Denying access to authorized users can be frustrating, but you know what's even worse? Incorrectly granting access to the wrong user. SSO technology is great, but not if it relies on just a single factor of authentication. Adding more authentication factors strengthen these systems.

Multi-factor authentication, or MFA, is a security measure, which requires a user to verify their identity in two or more ways to access a system or network. MFA combines two or more independent credentials, like knowledge and ownership, to prove that someone is who they claim to be.

SSO and MFA are often used in conjunction with one another to layer the defense capabilities of authentication systems. When both are used, organizations can ensure convenient access that is also secure.

A better approach to authentication

Single sign-on (SSO) is a technology that combines several different logins into one. More companies are turning to SSO as a solution to their authentication needs for three reasons:

1. **SSO improves the user experience** by eliminating the number of usernames and passwords people have to remember.
2. **Companies can lower costs** by streamlining how they manage connected services.
3. **SSO improves overall security** by reducing the number of access points attackers can target.

This technology became available in the mid-1990s as a way to combat *password fatigue*, which refers to people’s tendency to reuse passwords across services. Remembering many different passwords can be a challenge, but using the same password repeatedly is a major security risk. SSO solves this dilemma by shifting the burden of authentication away from the user.

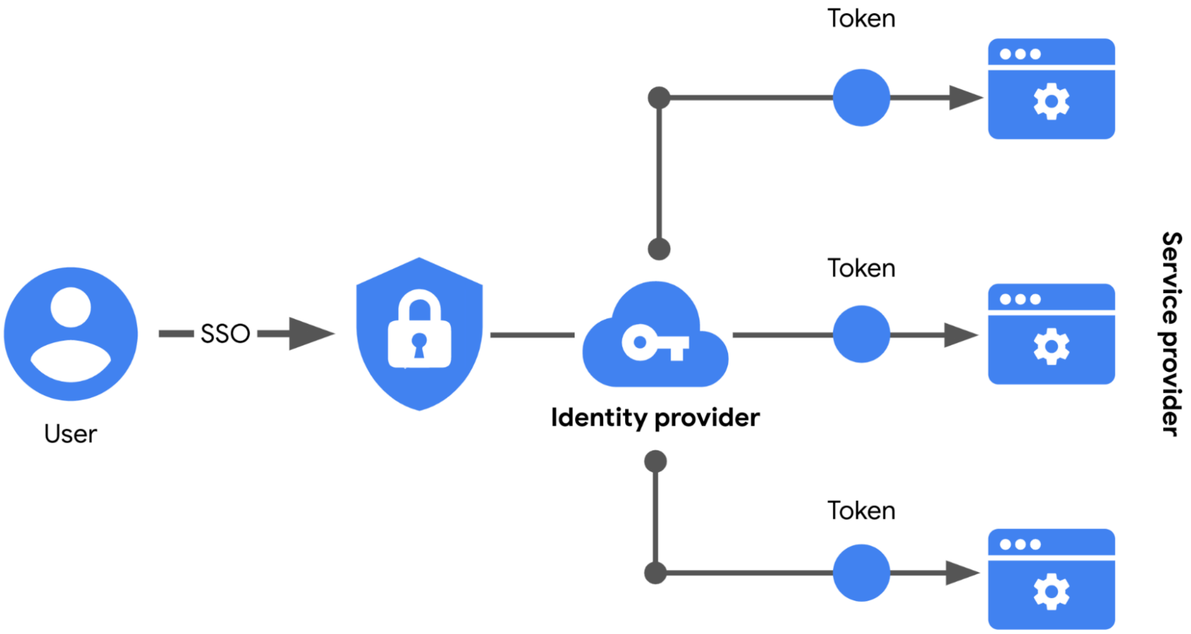
How SSO works

SSO works by automating how trust is established between a user and a service provider. Rather than placing the responsibility on an employee or customer, SSO solutions use trusted third-parties to prove that a user is who they claim to be. This is done through the exchange of encrypted access tokens between the identity provider and the service provider.

Similar to other kinds of digital information, these access tokens are exchanged using specific protocols. SSO implementations commonly rely on two different authentication protocols: LDAP and SAML. LDAP, which stands for Lightweight Directory Access Protocol, is mostly used to transmit information on-premises; SAML, which stands for Security Assertion Markup Language, is mostly used to transmit information off-premises, like in the cloud.

Note: LDAP and SAML protocols are often used together.

Here's an example of how SSO can connect a user to multiple applications with one access token:

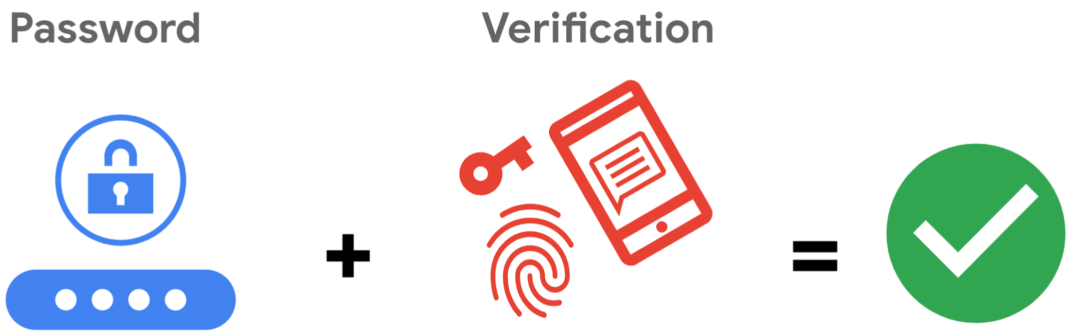


Limitations of SSO

Usernames and passwords alone are not always the most secure way of protecting sensitive information. SSO provides useful benefits, but there's still the risk associated with using one form of authentication. For example, a lost or stolen password could expose information across multiple services. Thankfully, there's a solution to this problem.

MFA to the rescue

Multi-factor authentication (MFA) requires a user to verify their identity in two or more ways to access a system or network. In a sense, MFA is similar to using an ATM to withdraw money from your bank account. First, you insert a debit card into the machine as one form of identification. Then, you enter your PIN number as a second form of identification. Combined, both steps, or factors, are used to verify your identity before authorizing you to access the account.



Strengthening authentication

MFA builds on the benefits of SSO. It works by having users prove that they are who they claim to be. The user must provide two factors (2FA) or three factors (3FA) to authenticate their identification. The MFA process asks users to provide these proofs, such as:

- **Something a user knows:** most commonly a username and password
- **Something a user has:** normally received from a service provider, like a one-time passcode (OTP) sent via SMS
- **Something a user is:** refers to physical characteristics of a user, like their fingerprints or facial scans

Requiring multiple forms of identification is an effective security measure, especially in cloud environments. It can be difficult for businesses in the cloud to ensure that the users remotely accessing their systems are not threat actors. MFA can reduce the risk of authenticating the wrong users by requiring forms of identification that are difficult to imitate or brute force.

The mechanisms of authorization

Access is as much about authorization as it is about authentication. One of the most important functions of access controls is how they assign responsibility for certain systems and processes. Next up in our exploration of access control systems are the mechanisms of authorization.

These protocols actually work closely together with authentication technologies. While one validates who the user is, the other determines what they're allowed to do. Let's take a look at the next part of the authentication, authorization, and accounting framework that protects private information.

Earlier, we learned about the principle of least privilege. Authorization is linked to the idea that access to information only lasts as long as needed. Authorization systems are also heavily influenced by this idea in addition to another important security principle, the separation of duties.

Separation of duties is the principle that users should not be given levels of authorization that will allow them to misuse a system. Separating duties reduces the risk of system failures and inappropriate behavior from users.

For example, a person responsible for providing customer service shouldn't also be authorized to rate their own performance. In this position, they could easily neglect their duties while continuing to give themselves high marks with no oversight. Similarly, if one person was authorized to develop and test a security system, they are much more likely to be unaware of its weaknesses.

Both the principle of least privilege and the concept of separating duties apply to more than just people. They apply to all systems including networks, databases, processes, and any other aspect of an organization. Ultimately, authorization depends on a system or user's role. When it comes to securing data over a network, there are a couple of frequently used access controls that you should be familiar with: HTTP basic auth and OAuth.

Have you ever wondered what the HTTP in web addresses stood for. It stands for hypertext transfer protocol, which is how communications are established over network. HTTP uses what is known as basic auth, the technology used to establish a user's request to access a server. Basic auth works by sending an identifier every time a user communicates with a web page.

Some websites still use basic auth to tell whether or not someone is authorized to access information on that site. However, their protocol is considered to be vulnerable to attacks because it transmits usernames and password openly over the network. Most websites today use HTTPS instead, which stands for hypertext transfer protocol secure. This protocol doesn't expose sensitive information, like access credentials, when communicating over the network.

Another secure authentication technology used today is OAuth. OAuth is an open-standard authorization protocol that shares designated access between applications. For example, you can tell Google that it's okay for another website to access your profile to create an account. Instead of requesting and sending sensitive usernames and passwords over the network, OAuth uses API tokens to verify access between you and a service provider.

An API token is a small block of encrypted code that contains information about a user. These tokens contain things like your identity, site permissions, and more. OAuth sends and receives access requests using API tokens by passing them from a server to a user's device.

Let's explore what's going on behind the scenes. When you authorize a site to create an account using your Google profile, all of Google's usual login protocols are still active. If you have multi-factor authentication enabled on your account, and you should, you'll still have the security benefits that it provides. API tokens minimize risks in a major way. These API tokens serve as an additional layer of encryption that helps to keep your Google password safe in the event of a breach on another platform.

Basic auth and OAuth are just a couple of examples of authorization tools that are designed with the principles of least privilege and separation of duty in mind. There are many other controls that help limit the risk of unauthorized access to information. In addition to controlling access, it's also important to monitor it.

Why we audit user activity

Accounting is the practice of monitoring the access logs of a system. These logs contain information like who accessed the system, and when they accessed it, and what resources they used.

Security analysts use access logs a lot. The data they contain is a helpful way to identify trends, like failed login attempts. They're also used to uncover hackers who have gained access to a system, and for detecting an incident, like a data breach.

In this field, access logs are essential. Oftentimes, analyzing them is the first procedure you'll follow when investigating a security event. So, how do access logs compile all this useful information? Let's examine this more closely.

Anytime a user accesses a system, they initiate what's called a session. A session is a sequence of network HTTP basic auth requests and responses associated with the same user, like when you visit a website. Access logs are essentially records of sessions that capture the moment a user enters a system until the moment they leave it.

Two actions are triggered when the session begins. The first is the creation of a session ID. A session ID is a unique token that identifies a user and their device while accessing the system. Session IDs are attached to the user until they either close their browser or the session times out.

The second action that takes place at the start of a session is an exchange of session cookies between a server and a user's device. A session cookie is a token that websites use to validate a session and determine how long that session should last. When cookies are exchanged between your computer and a server, your session ID is read to determine what information the website should show you.

Cookies make web sessions safer and more efficient. The exchange of tokens means that no sensitive information, like usernames and passwords, are shared. Session cookies prevent attackers from obtaining sensitive data. However, there's other damage that they can do. With a stolen cookie, an attacker can impersonate a user using their session token. This kind of attack is known as session hijacking.

Session hijacking is an event when attackers obtain a legitimate user's session ID. During these kinds of attacks, cyber criminals impersonate the user, causing all sorts of harm. Money or private data can be stolen. If, for example, hijackers obtain a single sign-on credential from stolen cookies, they can even gain access to additional systems that otherwise seem secure.

Security is more than simply combining processes and technologies to protect assets. Instead, security is about ensuring that these processes and technologies are creating a secure environment that supports a defense strategy. A key to doing this is implementing two fundamental security principles that limit access to organizational resources:

- The **principle of least privilege** in which a user is only granted the minimum level of access and authorization required to complete a task or function.
- **Separation of duties**, which is the principle that users should not be given levels of authorization that would allow them to misuse a system.

Both principles typically support each other. For example, according to least privilege, a person who needs permission to approve purchases from the IT department shouldn't have the permission to approve purchases from every department. Likewise, according to separation of duties, the person who can approve purchases from the IT department should be different from the person who can input new purchases.

In other words, least privilege *limits the access* that an individual receives, while separation of duties *divides responsibilities* among multiple people to prevent any one person from having too much control.

Note: Separation of duties is sometimes referred to as segregation of duties.

Previously, you learned about the authentication, authorization, and accounting (AAA) framework. Many businesses used this model to implement these two security principles and manage user access. In this reading, you'll learn about the other major framework for managing user access, identity and access management (IAM). You will learn about the similarities between AAA and IAM and how they're commonly implemented.

Identity and access management (IAM)

As organizations become more reliant on technology, regulatory agencies have put more pressure on them to demonstrate that they're doing everything they can to prevent threats. **Identity and access management** (IAM) is a collection of processes and technologies that helps organizations manage digital identities in their environment. Both AAA and IAM systems are designed to authenticate users, determine their access privileges, and track their activities within a system.

Either model used by your organization is more than a single, clearly defined system. They each consist of a collection of security controls that ensure the *right user* is granted access to the *right resources* at the *right time* and for the *right reasons*. Each of those four factors is determined by your organization's policies and processes.

Note: A user can either be a person, a device, or software.

Authenticating users

To ensure the right user is attempting to access a resource requires some form of proof that the user is who they claim to be. In a video on authentication controls, you learned that there are a few factors that can be used to authenticate a user:

- **Knowledge**, or something the user knows
- **Ownership**, or something the user possesses
- **Characteristic**, or something the user is

Authentication is mainly verified with login credentials. **Single sign-on** (SSO), a technology that combines several different logins into one, and **multi-factor authentication** (MFA), a security measure that requires a user to verify their identity in two or more ways to access a system or network, are other tools that organizations use to authenticate individuals and systems.

Pro tip: Another way to remember this authentication model is: something you know, something you have, and something you are.

User provisioning

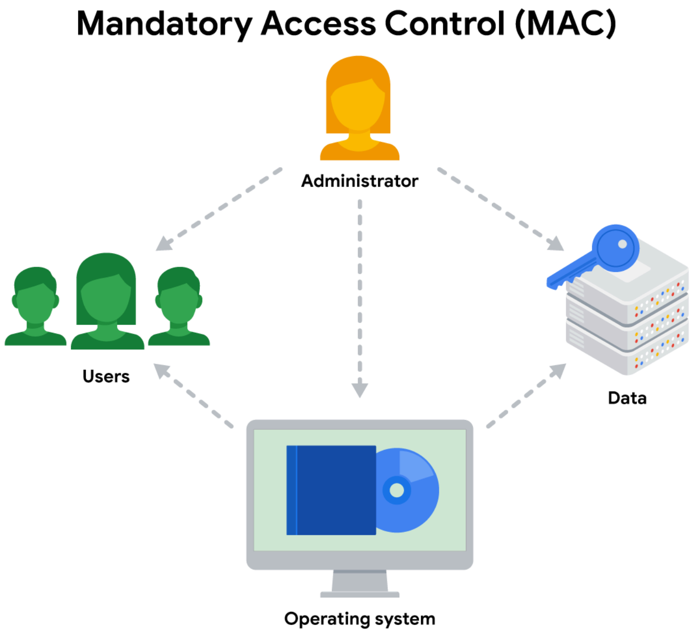
Back-end systems need to be able to verify whether the information provided by a user is accurate. To accomplish this, users must be properly provisioned. **User provisioning** is the process of creating and maintaining a user's digital identity. For example, a college might create a new user account when a new instructor is hired. The new account will be configured to provide access to instructor-only resources while they are teaching. Security analysts are routinely involved with provisioning users and their access privileges.

Pro tip: Another role analysts have in IAM is to deprovision users. This is an important practice that removes a user's access rights when they should no longer have them.

Granting authorization

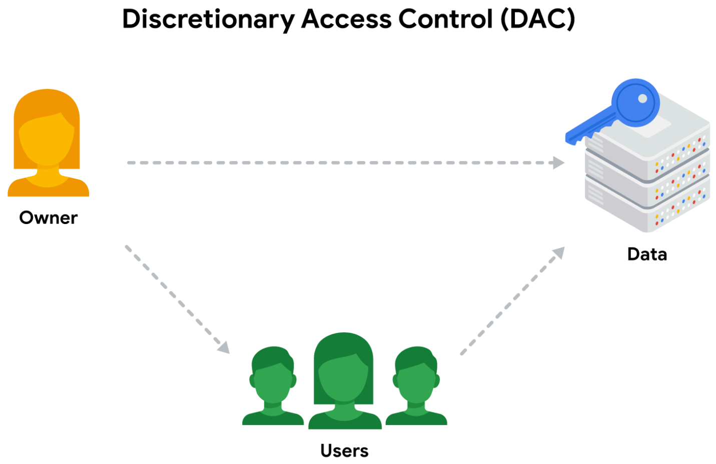
If the right user has been authenticated, the network should ensure the right resources are made available. There are three common frameworks that organizations use to handle this step of IAM:

- Mandatory access control (MAC)
- Discretionary access control (DAC)
- Role-based access control (RBAC)



Mandatory Access Control (MAC)

MAC is the strictest of the three frameworks. Authorization in this model is based on a strict need-to-know basis. Access to information must be granted manually by a central authority or system administrator. For example, MAC is commonly applied in law enforcement, military, and other government agencies where users must request access through a chain of command. MAC is also known as non-discretionary control because access isn't given at the discretion of the data owner.

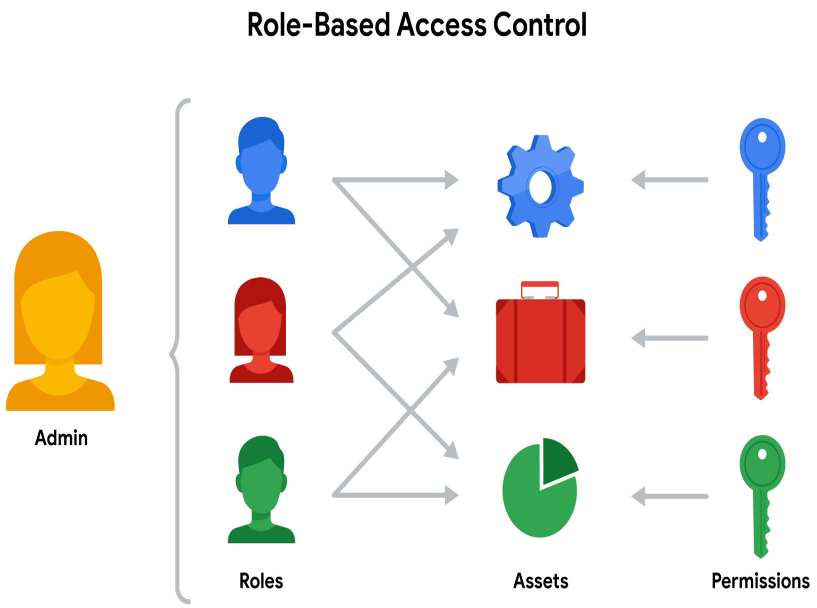


Discretionary Access Control (DAC)

DAC is typically applied when a data owner decides appropriate levels of access. One example of DAC is when the owner of a Google Drive folder shares editor, viewer, or commentor access with someone else.

Role-Based Access Control (RBAC)

RBAC is used when authorization is determined by a user's role within an organization. For example, a user in the marketing department may have access to user analytics but not network administration.



Access control technologies

Users often experience authentication and authorization as a single, seamless experience. In large part, that's due to access control technologies that are configured to work together. These tools offer the speed and automation needed by administrators to monitor and modify access rights. They also decrease errors and potential risks.

An organization's IT department sometimes develops and maintains customized access control technologies on their own. A typical IAM or AAA system consists of a user directory, a set of tools for managing data in that directory, an authorization system, and an auditing system. Some organizations create custom systems to tailor them to their security needs. However, building an in-house solution comes at a steep cost of time and other resources.

Instead, many organizations opt to license third-party solutions that offer a suite of tools that enable them to quickly secure their information systems. Keep in mind, security is about more than combining a bunch of tools. It's always important to configure these technologies so they can help to provide a secure environment.

Resources for more information

The identity and access management industry is growing at a rapid pace. As with other domains in security, it's important to stay informed.

- IDPro© is a professional organization dedicated to sharing essential IAM industry knowledge.

Module 3 - Vulnerabilities in Systems

Flaws in the system

Vulnerability management

A vulnerability is a weakness that can be exploited by a threat. That word, can, is an important part of this description. Why is that? Let's explore that together to find out more.

Imagine I handed you an important document and asked you to keep it safe. How would you do that? Some of you might first think about locking it up in a safe place. Behind this is the understanding that, because documents can be easily moved, they are vulnerable to theft. When other vulnerabilities come to mind, like how paper burns easily or doesn't resist water, you might add other protections.

Similar to this example, security teams plan to protect assets according to their vulnerabilities and how they can be exploited. In security, an exploit is a way of taking advantage of a vulnerability. Besides finding vulnerabilities, security planning relies a lot on thinking of exploits.

For example, there are burglars out there who want to cause harm. Homes have vulnerable systems that can be exploited by a burglar. An example are the windows. Glass is vulnerable to being broken. A burglar can exploit this vulnerability by using a rock to break the window. Thinking of this vulnerability and exploit ahead of time allows us to plan ahead. We can have an alarm system in place to scare the burglar away and alert the police.

Security teams spend a lot of time finding vulnerabilities and thinking of how they can be exploited. They do this with the process known as vulnerability management. Vulnerability management is the process of finding and patching vulnerabilities. Vulnerability management helps keep assets safe. It's a method of stopping threats before they can become a problem. Vulnerability management is a four step process. The first step is to identify vulnerabilities. The next step is to consider potential exploits of those vulnerabilities. Third is to prepare defenses against threats. And finally, the fourth step is to evaluate those defenses.

When the last step ends, the process starts again. Vulnerability management happens in a cycle. It's a regular part of what security teams do because there are always new vulnerabilities to be concerned about.

This is exactly why a diverse set of perspectives is useful! Having a wide range of backgrounds and experiences only strengthens security teams and their ability to find exploits. However, even large and diverse security teams can't keep track of everything.

New vulnerabilities are constantly being discovered. These are known as zero-day exploits. A zero-day is an exploit that was previously unknown. The term zero-day refers to the fact that the exploit is happening in real time with zero days to fix it. These kind of exploits are dangerous. They represent threats that haven't been planned for yet.

For example, we can anticipate the possibility of a burglar breaking into our home. We can plan for this type of threat by having defenses in place, like locks on the doors and windows. A zero-day exploit would be something totally unexpected, like the lock on the door falling off from intense heat. Zero-day exploits are things that don't normally come to mind. For example, this might be a new form of spyware infecting a popular website. When zero-day exploits happen, they can leave assets even more vulnerable to threats than they already are.

Vulnerability management is the process of finding vulnerabilities and fixing their exploits. That's why the process is performed regularly at most organizations. Perhaps the most important step of the process is identifying vulnerabilities.

Defense in depth strategy

Defense in depth is commonly referred to as the castle approach because it resembles the layered defenses of a castle.

In the Middle Ages, these structures were very difficult to penetrate. They featured different defenses, each unique in its design, that posed different challenges for attackers. For example, a water-filled barrier called a moat usually formed a circle around the castle, preventing threats like large groups of attackers from reaching the castle walls. The few soldiers that made it past the first layer of defense were then faced with a new challenge, giant stone walls. A vulnerability of these structures were that they could be climbed. If attackers tried exploiting that weakness, guess what? They were met with another layer of defense, watch towers, filled with defenders ready to shoot arrows and keep them from climbing! Each level of defense of these medieval structures minimized the risk of attacks by identifying vulnerabilities and implementing a security control should one system fail.

Defense in depth works in a similar way. The defense in depth concept can be used to protect any asset. It's mainly used in cybersecurity to protect information using a five layer design. Each layer features a number of security controls that protect information as it travels in and out of the model.

The first layer of defense in depth is the perimeter layer. This layer includes some technologies that we've already explored, like usernames and passwords. Mainly, this is a user authentication layer that filters external access. Its function is to only allow access to trusted partners to reach the next layer of defense.

Second, the network layer is more closely aligned with authorization. The network layer is made up of other technologies like network firewalls and others.

Next, is the endpoint layer. Endpoints refer to the devices that have access on a network. They could be devices like a laptop, desktop, or a server. Some examples of technologies that protect these devices are anti-virus software.

After that, we get to the application layer. This includes all the interfaces that are used to interact with technology. At this layer, security measures are programmed as part of an application. One common example is multi-factor authentication. You may be familiar with having to enter both your password and a code sent by SMS. This is part of the application layer of defense.

And finally, the fifth layer of defense is the data layer. At this layer, we've arrived at the critical data that must be protected, like personally identifiable information. One security control that is important here in this final layer of defense is asset classification.

What is OWASP?

OWASP is a nonprofit foundation that works to improve the security of software. OWASP is an open platform that security professionals from around the world use to share information, tools, and events that are focused on securing the web.

The OWASP Top 10

One of OWASP’s most valuable resources is the OWASP Top 10. The organization has published this list since 2003 as a way to spread awareness of the web’s most targeted vulnerabilities. The Top 10 mainly applies to new or custom made software. Many of the world's largest organizations reference the OWASP Top 10 during application development to help ensure their programs address common security mistakes.

Pro tip: OWASP’s Top 10 is updated every few years as technologies evolve. Rankings are based on how often the vulnerabilities are discovered and the level of risk they present.

Note: Auditors also use the OWASP Top 10 as one point of reference when checking for regulatory compliance.

Common vulnerabilities

Businesses often make critical security decisions based on the vulnerabilities listed in the OWASP Top 10. This resource influences how businesses design new software that will be on their network, unlike the CVE® list, which helps them identify improvements to existing programs. These are the most regularly listed vulnerabilities that appear in their rankings to know about:

Broken access control

Access controls limit what users can do in a web application. For example, a blog might allow visitors to post comments on a recent article but restricts them from deleting the article entirely. Failures in these mechanisms can lead to unauthorized information disclosure, modification, or destruction. They can also give someone unauthorized access to other business applications.

Cryptographic failures

Information is one of the most important assets businesses need to protect. Privacy laws such as General Data Protection Regulation (GDPR) require sensitive data to be protected by effective encryption methods. Vulnerabilities can occur when businesses fail to encrypt things like personally identifiable information (PII). For example, if a web application uses a weak hashing algorithm, like MD5, it's more at risk of suffering a data breach.

Injection

Injection occurs when malicious code is inserted into a vulnerable application. Although the app appears to work normally, it does things that it wasn't intended to do. Injection attacks can give threat actors a backdoor into an organization's information system. A common target is a website's login form. When these forms are vulnerable to injection, attackers can insert malicious code that gives them access to modify or steal user credentials.

Insecure design

Applications should be designed in such a way that makes them resilient to attack. When they aren't, they're much more vulnerable to threats like injection attacks or malware infections. Insecure design refers to a wide range of missing or poorly implemented security controls that should have been programmed into an application when it was being developed.

Security misconfiguration

Misconfigurations occur when security settings aren't properly set or maintained. Companies use a variety of different interconnected systems. Mistakes often happen when those systems aren't properly set up or audited. A common example is when businesses deploy equipment, like a network server, using default settings. This can lead businesses to use settings that fail to address the organization's security objectives.

Vulnerable and outdated components

Vulnerable and outdated components is a category that mainly relates to application development. Instead of coding everything from scratch, most developers use open-source libraries to complete their projects faster and easier. This publicly available software is maintained by communities of programmers on a volunteer basis. Applications that use vulnerable components that have not been maintained are at greater risk of being exploited by threat actors.

Identification and authentication failures

Identification is the keyword in this vulnerability category. When applications fail to recognize who should have access and what they're authorized to do, it can lead to serious problems. For example, a home Wi-Fi router normally uses a simple login form to keep unwanted guests off the network. If this defense fails, an attacker can invade the homeowner's privacy.

Software and data integrity failures

Software and data integrity failures are instances when updates or patches are inadequately reviewed before implementation. Attackers might exploit these weaknesses to deliver malicious software. When that occurs, there can be serious downstream effects. Third parties are likely to become infected if a single system is compromised, an event known as a supply chain attack.
A famous example of a supply chain attack is the SolarWinds cyber attack (2020) where hackers injected malicious code into software updates that the company unknowingly released to their customers.

Security logging and monitoring failures

In security, it’s important to be able to log and trace back events. Having a record of events like user login attempts is critical to finding and fixing problems. Sufficient monitoring and incident response is equally important.

Server-side request forgery

Companies have public and private information stored on web servers. When you use a hyperlink or click a button on a website, a request is sent to a server that should validate who you are, fetch the appropriate data, and then return it to you.

Server-side request forgeries (SSRFs) are when attackers manipulate the normal operations of a server to read or update other resources on that server. These are possible when an application on the server is vulnerable. Malicious code can be carried by the vulnerable app to the host server that will fetch unauthorized data.

Information vs intelligence

The terms intelligence and information are often used interchangeably, making it easy to mix them up. Both are important aspects of cybersecurity that differ in their focus and objectives.
Information refers to the collection of raw data or facts about a specific subject. *Intelligence*, on the other hand, refers to the analysis of information to produce knowledge or insights that can be used to support decision-making.
For example, new information might be released about an update to the operating system (OS) that's installed on your organization's workstations. Later, you might find that new cyber threats have been linked to this new update by researching multiple cybersecurity news resources. The analysis of this information can be used as intelligence to guide your organization's decision about installing the OS updates on employee workstations.
In other words, intelligence is derived from information through the process of analysis, interpretation, and integration. Gathering information and intelligence are both important aspects of cybersecurity.

Intelligence improves decision-making

Businesses often use information to gain insights into the behavior of their customers. Insights, or intelligence, can then be used to improve their decision making. In security, open-source information is used in a similar way to gain insights into threats and vulnerabilities that can pose risks to an organization.
OSINT plays a significant role in **information security (InfoSec)**, which is the practice of keeping data in all states away from unauthorized users.
For example, a company's InfoSec team is responsible for protecting their network from potential threats. They might utilize OSINT to monitor online forums and hacker communities for discussions

about emerging vulnerabilities. If they come across a forum post discussing a newly discovered weakness in a popular software that the company uses, the team can quickly assess the risk, prioritize patching efforts, and implement necessary safeguards to prevent an attack.
Here are some of the ways OSINT can be used to generate intelligence:

- To provide insights into cyber attacks
- To detect potential data exposures
- To evaluate existing defenses
- To identify unknown vulnerabilities

Collecting intelligence is sometimes part of the vulnerability management process. Security teams might use OSINT to develop profiles of potential targets and make data driven decisions on improving their defenses.

OSINT tools

There's an enormous amount of open-source information online. Finding relevant information that can be used to gather intelligence is a challenge. Information can be gathered from a variety of sources, such as search engines, social media, discussion boards, blogs, and more. Several tools also exist that can be used in your intelligence gathering process. Here are just a few examples of tools that you can explore:

- VirusTotal is a service that allows anyone to analyze suspicious files, domains, URLs, and IP addresses for malicious content.
- MITRE ATT&CK® is a knowledge base of adversary tactics and techniques based on real-world observations.
- OSINT Framework is a web-based interface where you can find OSINT tools for almost any kind of source or platform.
- Have I been Pwned is a tool that can be used to search for breached email accounts.

There are numerous other OSINT tools that can be used to find specific types of information. Remember, information can be gathered from a variety of sources. Ultimately, it's your responsibility to thoroughly research any available information that's relevant to the problem you're trying to solve.

Identify system vulnerabilities

Vulnerability scanners are important tools that you'll likely use in the field. In this reading, you'll explore how vulnerability scanners work and the types of scans they can perform.

What is a vulnerability scanner?

A **vulnerability scanner** is software that automatically compares known vulnerabilities and exposures against the technologies on the network. In general, these tools scan systems to find misconfigurations or programming flaws.
Scanning tools are used to analyze each of the five attack surfaces that you learned about in the video about the defense in depth strategy:

1. **Perimeter layer**, like authentication systems that validate user access
2. **Network layer**, which is made up of technologies like network firewalls and others
3. **Endpoint layer**, which describes devices on a network, like laptops, desktops, or servers
4. **Application layer**, which involves the software that users interact with

5. **Data layer**, which includes any information that's stored, in transit, or in use

When a scan of any layer begins, the scanning tool compares the findings against databases of security threats. At the end of the scan, the tool flags any vulnerabilities that it finds and adds them to its reference database. Each scan adds more information to the database, helping the tool be more accurate in its analysis.

Note: Vulnerability databases are also routinely updated by the company that designed the scanning software.

Performing scans

Vulnerability scanners are meant to be non-intrusive. Meaning, they don't break or take advantage of a system like an attacker would. Instead, they simply scan a surface and alert you to any potentially unlocked doors in your systems.

Note: While vulnerability scanners are non-intrusive, there are instances when a scan can inadvertently cause issues, like crash a system.

There are a few different ways that these tools are used to scan a surface. Each approach corresponds to the pathway a threat actor might take. Next, you can explore each type of scan to get a clearer picture of this.

External vs. internal

External and internal scans simulate an attacker's approach.

External scans test the perimeter layer outside of the internal network. They analyze outward facing systems, like websites and firewalls. These kinds of scans can uncover vulnerable things like vulnerable network ports or servers.

Internal scans start from the opposite end by examining an organization's internal systems. For example, this type of scan might analyze application software for weaknesses in how it handles user input.

Authenticated vs. unauthenticated

Authenticated and unauthenticated scans simulate whether or not a user has access to a system.

Authenticated scans might test a system by logging in with a real user account or even with an admin account. These service accounts are used to check for vulnerabilities, like broken access controls.

Unauthenticated scans simulate external threat actors that do not have access to your business resources. For example, a scan might analyze file shares within the organization that are used to house internal-only documents. Unauthenticated users should receive "access denied" results if they tried opening these files. However, a vulnerability would be identified if you were able to access a file.

Limited vs. comprehensive

Limited and comprehensive scans focus on particular devices that are accessed by internal and external users.

Limited scans analyze particular devices on a network, like searching for misconfigurations on a firewall.

Comprehensive scans analyze all devices connected to a network. This includes operating systems, user databases, and more.

Pro tip: Discovery scanning should be done prior to limited or comprehensive scans. Discovery scanning is used to get an idea of the computers, devices, and open ports that are on a network.

Tip: To explore vulnerability scanner software commonly used in the cybersecurity industry, in your preferred browser enter search terms similar to “popular vulnerability scanner software” and/or “open source vulnerability scanner software used in cybersecurity”.

Patching gaps in security

An outdated computer is a lot like a house with unlocked doors. Malicious actors use these gaps in security the same way, to gain unauthorized access. Software updates are similar to locking the doors to keep them out.

A **patch update** is a software and operating system update that addresses security vulnerabilities within a program or product. Patches usually contain bug fixes that address common security vulnerabilities and exposures.

Note: Ideally, patches address common vulnerabilities and exposures before malicious hackers find them. However, patches are sometimes developed as a result of a **zero-day**, which is an exploit that was previously unknown.

Common update strategies

When software updates become available, clients and users have two installation options:

- Manual updates
- Automatic updates

As you’ll learn, each strategy has both benefits and disadvantages.

Manual updates

A manual deployment strategy relies on IT departments or users obtaining updates from the developers. Home office or small business environments might require you to find, download, and install updates yourself. In enterprise settings, the process is usually handled with a configuration management tool. These tools offer a range of options to deploy updates, like to all clients on your network or a select group of users.

Advantage: An advantage of manual update deployment strategies is control. That can be useful if software updates are not thoroughly tested by developers, leading to instability issues.

Disadvantage: A drawback to manual update deployments is that critical updates can be forgotten or disregarded entirely.

Automatic updates

An automatic deployment strategy takes the opposite approach. With this option, finding, downloading, and installing updates can be done by the system or application.

Pro tip: The Cybersecurity and Infrastructure Security Agency (CISA) recommends using automatic options whenever they’re available.

Certain permissions need to be enabled by users or IT groups before updates can be installed, or pushed, when they're available. It is up to the developers to adequately test their patches before release.

Advantage: An advantage to automatic updates is that the deployment process is simplified. It also keeps systems and software current with the latest, critical patches.

Disadvantage: A drawback to automatic updates is that instability issues can occur if the patches were not thoroughly tested by the vendor. This can result in performance problems and a poor user experience.

End-of-life software

Sometimes updates are not available for a certain type of software known as end-of-life (EOL) software. All software has a lifecycle. It begins when it's produced and ends when a newer version is released. At that point, developers must allocate resources to the newer versions, which leads to EOL software. While the older software is still useful, the manufacturer no longer supports it.

Note: Patches and updates are very different from upgrades. *Upgrades* refer to completely new versions of hardware or software that can be purchased.

CISA recommends discontinuing the use of EOL software because it poses an unfixable risk to systems. But, this recommendation is not always followed. Replacing EOL technology can be costly for businesses and individual users.

The risks that EOL software presents continues to grow as more connected devices enter the marketplace. For example, there are billions of Internet of Things (IoT) devices, like smart light bulbs, connected to home and work networks. In some business settings, all an attacker needs is a single unpatched device to gain access to the network and cause problems.

Penetration testing

A **penetration test**, or pen test, is a simulated attack that helps identify vulnerabilities in systems, networks, websites, applications, and processes. The simulated attack in a pen test involves using the same tools and techniques as malicious actors in order to mimic a real life attack. Since a pen test is an authorized attack, it is considered to be a form of ethical hacking. Unlike a vulnerability assessment that finds weaknesses in a system's security, a pen test exploits those weaknesses to determine the potential consequences if the system breaks or gets broken into by a threat actor.

For example, the cybersecurity team at a financial company might simulate an attack on their banking app to determine if there are weaknesses that would allow an attacker to steal customer information or illegally transfer funds. If the pen test uncovers misconfigurations, the team can address them and improve the overall security of the app.

Note: Organizations that are regulated by PCI DSS, HIPAA, or GDPR must routinely perform penetration testing to maintain compliance standards.

Learning from varied perspectives

These authorized attacks are performed by pen testers who are skilled in programming and network architecture. Depending on their objectives, organizations might use a few different approaches to penetration testing:

- Red team tests *simulate attacks* to identify vulnerabilities in systems, networks, or applications.
- Blue team tests focus on *defense and incident response* to validate an organization's existing security systems.
- Purple team tests are *collaborative*, focusing on improving the security posture of the organization by combining elements of red and blue team exercises.

Red team tests are commonly performed by independent pen testers who are hired to evaluate internal systems. Although, cybersecurity teams may also have their own pen testing experts. Regardless of the approach, penetration testers must make an important decision before simulating an attack: *How much access and information do I need?*

Penetration testing strategies

There are three common penetration testing strategies:

- **Open-box testing** is when the tester has the same privileged access that an internal developer would have—information like system architecture, data flow, and network diagrams. This strategy goes by several different names, including internal, full knowledge, white-box, and clear-box penetration testing.
- **Closed-box testing** is when the tester has little to no access to internal systems—similar to a malicious hacker. This strategy is sometimes referred to as external, black-box, or zero knowledge penetration testing.
- **Partial knowledge testing** is when the tester has limited access and knowledge of an internal system—for example, a customer service representative. This strategy is also known as gray-box testing.

Closed box testers tend to produce the most accurate simulations of a real-world attack. Nevertheless, each strategy produces valuable results by demonstrating how an attacker might infiltrate a system and what information they could access.

Becoming a penetration tester

Penetration testers are in-demand in the fast growing field of cybersecurity. All of the skills you're learning in this program can help you advance towards a career in pen testing:

- Network and application security
- Experience with operating systems, like Linux
- Vulnerability analysis and threat modeling
- Detection and response tools
- Programming languages, like Python and BASH
- Communication skills

Programming skills are very helpful in penetration testing because it's often performed on software and IT systems. With enough practice and dedication, cybersecurity professionals at any level can develop the skills needed to be a pen tester.

Bug bounty programs

Organizations commonly run bug bounty programs which offer freelance pen testers financial rewards for finding and reporting vulnerabilities in their products. Bug bounties are great opportunities for amateur security professionals to participate and grow their skills.
Pro tip: HackerOne is a community of ethical hackers where you can find active bug bounties to participate in.

Cyber attacker mindset

Approach cybersecurity with an attacker mindset

Cybersecurity is a continuously changing field. It's a fast-paced environment where new threats and innovative technologies can disrupt your plans at a moment's notice. As a security professional, it’s up to you to be prepared by anticipating change.

This all starts with identifying vulnerabilities. In a video, you learned about the importance of **vulnerability assessments,** the internal review process of an organization's security systems. In this reading, you will learn how you can use the findings of a vulnerability assessment proactively by analyzing them from the perspective of an attacker.

Being prepared for anything

Having a plan should things go wrong is important. But how do you figure out what to plan for? In this field, teams often conduct simulations of things that can go wrong as part of their vulnerability management strategy. One way this is done is by applying an attacker mindset to the weaknesses they discover.

Applying an attacker mindset is a lot like conducting an experiment. It's about causing problems in a controlled environment and evaluating the outcome to gain insights. Adopting an attacker mindset is a beneficial skill in security because it offers a different perspective about the challenges you're trying to solve. The insights you gain can be valuable when it's time to establish a security plan or modify an existing one.

Simulating threats

One method of applying an attacker mindset is using attack simulations. These activities are normally performed in one of two ways: *proactively* and *reactively*. Both approaches share a common goal, which is to make systems safer.

- *Proactive simulations* assume the role of an attacker by exploiting vulnerabilities and breaking through defenses. This is sometimes called a red team exercise.
- *Reactive simulations* assume the role of a defender responding to an attack. This is sometimes called a blue team exercise.

Each kind of simulation is a team effort that you might be involved with as an analyst.

Proactive teams tend to spend more time planning their attacks than performing them. If you find yourself engaged in one of these exercises, your team will likely deploy a range of tactics. For example, they might persuade staff into disclosing their login credentials using fictitious emails to evaluate security awareness at the company.

On the other hand, reactive teams dedicate their efforts to gathering information about the assets they're protecting. This is commonly done with the assistance of vulnerability scanning tools.

Scanning for trouble

You might recall that a **vulnerability scanner** is software that automatically compares existing common vulnerabilities and exposures against the technologies on the network. Vulnerability scanners are frequently used in the field. Security teams employ a variety of scanning techniques to uncover weaknesses in their defenses. Reactive simulations often rely on the results of a scan to weigh the risks and determine ways to remediate a problem.

For example, a team conducting a reactive simulation might perform an external vulnerability scan of their network. The entire exercise might follow the steps you learned in a video about vulnerability assessments:

- **Identification:** A vulnerable server is flagged because it's running an outdated operating system (OS).

- **Vulnerability analysis:** Research is done on the outdated OS and its vulnerabilities.
- **Risk assessment:** After doing your due diligence, the severity of each vulnerability is scored and the impact of not fixing it is evaluated.
- **Remediation**: Finally, the information that you've gathered can be used to address the issue.

During an activity like this, you'll often produce a report of your findings. These can be brought to the attention of service providers or your supervisors. Clearly communicating the results of these exercises to others is an important skill to develop as a security professional.

Finding innovative solutions

Many security controls that you've learned about were created as a reactive response to risks. That's because criminals are continually looking for ways to bypass existing defenses. Effectively applying an attacker mindset will require you to stay knowledgeable of security trends and emerging technologies.
Pro tip: Resources like NISTs National Vulnerability Database (NVD) can help you remain current on common vulnerabilities.

Types of threat actors

Anticipating attacks is an important skill you'll need to be an effective security professional. Developing this skill requires you to have an open and flexible mindset about where attacks can come from. Previously, you learned about **attack surfaces**, which are all the potential vulnerabilities that a threat actor could exploit.
Networks, servers, devices, and staff are examples of attack surfaces that can be exploited. Security teams of all sizes regularly find themselves defending these surfaces due to the expanding digital landscape. The key to defending any of them is to limit access to them.
In this reading, you'll learn more about threat actors and the types of risks they pose. You'll also explore the most common features of an attack surface that threat actors can exploit.

Threat actors

A **threat actor** is any person or group who presents a security risk. This broad definition refers to people inside and outside an organization. It also includes individuals who intentionally pose a threat, and those that accidentally put assets at risk. That's a wide range of people!
Threat actors are normally divided into five categories based on their motivations:

- **Competitors** refers to rival companies who pose a threat because they might benefit from leaked information.
- **State actors** are government intelligence agencies.
- **Criminal syndicates** refer to organized groups of people who make money from criminal activity.
- **Insider threats** can be any individual who has or had authorized access to an organization's resources. This includes employees who accidentally compromise assets or individuals who purposefully put them at risk for their own benefit.
- **Shadow IT** refers to individuals who use technologies that lack IT governance. A common example is when an employee uses their personal email to send work-related communications.

In the digital attack surface, these threat actors often gain unauthorized access by hacking into systems. By definition, a **hacker** is any person who uses computers to gain access to computer systems, networks, or data. Similar to the term threat actor, hacker is also an umbrella term. When used alone, the term fails to capture a threat actor's intentions.

Types of hackers

Because the formal definition of a hacker is broad, the term can be a bit ambiguous. In security, it applies to three types of individuals based on their intent:

1. Unauthorized hackers
2. Authorized, or ethical, hackers
3. Semi-authorized hackers

An unauthorized hacker, or unethical hacker, is an individual who uses their programming skills to commit crimes. Unauthorized hackers are also known as malicious hackers. Skill level ranges widely among this category of hacker. For example, there are hackers with limited skills who can't write their own malicious software, sometimes called *script kiddies***.** Unauthorized hackers like this carry out attacks using pre-written code that they obtain from other, more skilled hackers.

Authorized, or ethical, hackers refer to individuals who use their programming skills to improve an organization's overall security. These include internal members of a security team who are concerned with testing and evaluating systems to secure the attack surface. They also include external security vendors and freelance hackers that some companies incentivize to find and report vulnerabilities, a practice called **bug bounty** programs.

Semi-authorized hackers typically refer to individuals who might violate ethical standards, but are not considered malicious. For example, a **hacktivist** is a person who might use their skills to achieve a political goal. One might exploit security vulnerabilities of a public utility company to spread awareness of their existence. The intentions of these types of threat actors is often to expose security risks that should be addressed before a malicious hacker finds them.

Advanced persistent threats

Many malicious hackers find their way into a system, cause trouble, and then leave. But on some occasions, threat actors stick around. These kinds of events are known as advanced persistent threats, or APTs.

An **advanced persistent threat (APT)** refers to instances when a threat actor maintains unauthorized access to a system for an extended period of time. The term is mostly associated with nation states and state-sponsored actors. Typically, an APT is concerned with surveilling a target to gather information. They then use the intel to manipulate government, defense, financial, and telecom services.

Just because the term is associated with state actors does not mean that private businesses are safe from APTs. These kinds of threat actors are stealthy because hacking into another government agency or utility is costly and time consuming. APTs will often target private organizations first as a step towards gaining access to larger entities.

Access points

Each threat actor has a unique motivation for targeting an organization's assets. Keeping them out takes more than knowing their intentions and capabilities. It's also important to recognize the types of attack vectors they'll use.

For the most part, threat actors gain access through one of these attack vector categories:

- **Direct access**, referring to instances when they have physical access to a system
- **Removable media**, which includes portable hardware, like USB flash drives
- **Social media platforms** that are used for communication and content sharing

- **Email**, including both personal and business accounts
- **Wireless networks** on premises
- **Cloud services** usually provided by third-party organizations
- **Supply chains** like third-party vendors that can present a backdoor into systems

Any of these attack vectors can provide access to a system. Recognizing a threat actor's intentions can help you determine which access points they might target and what ultimate goals they could have. For example, remote workers are more likely to present a threat via email than a direct access threat.

Fortify against brute force cyber attacks

Usernames and passwords are one of the most common and important security controls in use today. They're like the door lock that organizations use to restrict access to their networks, services, and data. But a major issue with relying on login credentials as a critical line of defense is that they're vulnerable to being stolen and guessed by attackers.

In a video, you learned that **brute force attacks** are a trial-and-error process of discovering private information. In this reading, you'll learn about the many tactics and tools used by threat actors to perform brute force attacks. You'll also learn prevention strategies that organizations can use to defend against them.

A matter of trial and error

One way of opening a closed lock is trying as many combinations as possible. Threat actors sometimes use similar tactics to gain access to an application or a network.

Attackers use a variety of tactics to find their way into a system:

- *Simple brute force attacks* are an approach in which attackers guess a user's login credentials. They might do this by entering any combination of username and password that they can think of until they find the one that works.
- *Dictionary attacks* are a similar technique except in these instances attackers use a list of commonly used credentials to access a system. This list is similar to matching a definition to a word in a dictionary.
- *Reverse brute force attacks* are similar to dictionary attacks, except they start with a single credential and try it in various systems until a match is found.
- *Credential stuffing* is a tactic in which attackers use stolen login credentials from previous data breaches to access user accounts at another organization. A specialized type of credential stuffing is called *pass the hash*. These attacks reuse stolen, unsalted hashed credentials to trick an authentication system into creating a new authenticated user session on the network.

Note: Besides access credentials, encrypted information can sometimes be brute forced using a technique known as *exhaustive key search*.

Each of these methods involve a lot of guess work. Brute forcing your way into a system can be a tedious and time consuming process—especially when it's done manually. That's why threat actors often use tools to conduct their attacks.

Tools of the trade

There are so many combinations that can be used to create a single set of login credentials. The number of characters, letters, and numbers that can be mixed together is truly incredible. When done manually, it could take someone years to try every possible combination.

Instead of dedicating the time to do this, attackers often use software to do the guess work for them. These are some common brute forcing tools:

- Aircrack-ng
- Hashcat
- John the Ripper
- Ophcrack
- THC Hydra

Sometimes, security professionals use these tools to test and analyze their own systems. They each serve different purposes. For example, you might use Aircrack-ng to test a Wi-Fi network for vulnerabilities to brute force attack.

Prevention measures

Organizations defend against brute force attacks with a combination of technical and managerial controls. Each make cracking defense systems through brute force less likely:

- Hashing and salting
- Multi-factor authentication (MFA)
- CAPTCHA
- Password policies

Technologies, like multi-factor authentication (MFA), reinforce each login attempt by requiring a second or third form of identification. Other important tools are CAPTCHA and effective password policies.

Hashing and salting

Hashing converts information into a unique value that can then be used to determine its integrity. **Salting** is an additional safeguard that's used to strengthen hash functions. It works by adding random characters to data, like passwords. This increases the length and complexity of hash values, making them harder to brute force and less susceptible to dictionary attacks.

Multi-factor authentication (MFA)

Multi-factor authentication (MFA) is a security measure that requires a user to verify their identity in two or more ways to access a system or network. MFA is a layered approach to protecting information. MFA limits the chances of brute force attacks because unauthorized users are unlikely to meet each authentication requirement even if one credential becomes compromised.

CAPTCHA

CAPTCHA stands for Completely Automated Public Turing test to tell Computers and Humans Apart. It is known as a challenge-response authentication system. CAPTCHA asks users to complete a simple test that proves they are human and not software that's trying to brute force a password.

Here are common CAPTCHA examples:

There are two types of CAPTCHA tests. One scrambles and distorts a randomly generated sequence of letters and/or numbers and asks users to enter them into a text box. The other test asks users to match images to a randomly generated word. You've likely had to pass a CAPTCHA test when accessing a web service that contains sensitive information, like an online bank account.

Password policy

Organizations use these managerial controls to standardize good password practices across their business. For example, one of these policies might require users to create passwords that are at least 8 characters long and feature a letter, number, and symbol. Other common requirements can include password lockout policies. For example, a password lockout can limit the number of login attempts before access to an account is suspended and require users to create new, unique passwords after a certain amount of time.

The purpose of each of these requirements is to create more possible password combinations. This lengthens the amount of time it takes an attacker to find one that will work. The National Institute of Standards and Technology (NIST) Special Publication 800-63B provides detailed guidance that organizations can reference when creating their own password policies.

Terms and definitions from Course 5, Module 3

- **Advanced persistent threat (APT):** An instance when a threat actor maintains unauthorized access to a system for an extended period of time
- **Attack surface:** All the potential vulnerabilities that a threat actor could exploit
- **Attack tree:** A diagram that maps threats to assets
- **Attack vector:** The pathways attackers use to penetrate security defenses
- **Bug bounty:** Programs that encourage freelance hackers to find and report vulnerabilities
- **Common Vulnerabilities and Exposures (CVE®) list:** An openly accessible dictionary of known vulnerabilities and exposures
- **Common Vulnerability Scoring System (CVSS):** A measurement system that scores the severity of a vulnerability
- **CVE Numbering Authority (CNA):** An organization that volunteers to analyze and distribute information on eligible CVEs
- **Defense in depth:** A layered approach to vulnerability management that reduces risk
- **Exploit:** A way of taking advantage of a vulnerability
- **Exposure:** A mistake that can be exploited by a threat
- **Hacker:** Any person who uses computers to gain access to computer systems, networks, or data
- **MITRE:** A collection of non-profit research and development centers
- **Security hardening:** The process of strengthening a system to reduce its vulnerability and attack surface
- **Threat actor:** Any person or group who presents a security risk
- **Vulnerability:** A weakness that can be exploited by a threat
- **Vulnerability assessment:** The internal review process of a company's security systems
- **Vulnerability management:** The process of finding and patching vulnerabilities
- **Vulnerability scanner:** Software that automatically compares existing common vulnerabilities and exposures against the technologies on the network
- **Zero-day:** An exploit that was previously unknown

Module 4 - Threats to asset security

Social Engineering

Social engineering attacks are a popular choice among threat actors. That's because it's often easier to trick people into providing them with access, information, or money than it is to exploit a software or network vulnerability.

As you might recall, **social engineering** is a manipulation technique that exploits human error to gain private information, access, or valuables. It's an umbrella term that can apply to a broad range of attacks. Each technique is designed to capitalize on the trusting nature of people and their willingness to help. In this reading, you will learn about specific social engineering tactics to watch out for. You'll also learn ways that organizations counter these threats.

Social engineering risks

Social engineering is a form of deception that takes advantage of the way people think. It preys on people's natural feelings of curiosity, generosity, and excitement. Threat actors turn those feelings against their targets by affecting their better judgment. Social engineering attacks can be incredibly harmful because of how easy they can be to accomplish.

One of the highest-profile social engineering attacks that occurred in recent years was the *Twitter Hack of 2020*. During that incident, a group of hackers made phone calls to Twitter employees pretending to be from the IT department. Using this basic scam, the group managed to gain access to the organization's network and internal tools. This allowed them to take over the accounts of high-profile users, including politicians, celebrities, and entrepreneurs.

Attacks like this are just one example of the chaos threat actors can create using basic social engineering techniques. These attacks present serious risks because they don't require sophisticated computer skills to perform. Defending against them requires a multi-layered approach that combines technological controls with user awareness.

Signs of an attack

Oftentimes, people are unable to tell that an attack is happening until it's too late. Social engineering is such a dangerous threat because it typically allows attackers to bypass technological defenses that are in their way. Although these threats are difficult to prevent, recognizing the signs of social engineering is a key to reducing the likelihood of a successful attack.

These are common types of social engineering to watch out for:

- **Baiting** is a social engineering tactic that tempts people into compromising their security. A common example is USB baiting that relies on someone finding an infected USB drive and plugging it into their device.
- **Phishing** is the use of digital communications to trick people into revealing sensitive data or deploying malicious software. It is one of the most common forms of social engineering, typically performed via email.
- **Quid pro quo** is a type of baiting used to trick someone into believing that they'll be rewarded in return for sharing access, information, or money. For example, an attacker might impersonate a loan officer at a bank and call customers offering them a lower interest rate on their credit card. They'll tell the customers that they simply need to provide their account details to claim the deal.
- **Tailgating** is a social engineering tactic in which unauthorized people follow an authorized person into a restricted area. This technique is also sometimes referred to as piggybacking.
- **Watering hole** is a type of attack when a threat actor compromises a website frequently visited by a specific group of users. Oftentimes, these watering hole sites are infected with malicious software. An example is the *Holy Water attack of 2020* that infected various religious, charity, and volunteer websites.

Attackers might use any of these techniques to gain unauthorized access to an organization. Everyone is vulnerable to them, from entry-level employees to senior executives. However, you can reduce the risks of social engineering attacks at any business by teaching others what to expect.

Encouraging caution

Spreading awareness usually starts with comprehensive security training. When it comes to social engineering, there are three main areas to focus on when teaching others:

- **Stay alert** of suspicious communications and unknown people, especially when it comes to email. For example, look out for spelling errors and double-check the sender's name and email address.
- **Be cautious** about sharing information, especially over social media. Threat actors often search these platforms for any information they can use to their advantage.
- **Control curiosity** when something seems too good to be true. This can include wanting to click on attachments or links in emails and advertisements.

Pro tip: Implementing technologies like firewalls, multi-factor authentication (MFA), block lists, email filtering, and others helps layers the defenses should someone make a mistake.

Ideally, security training extends beyond employees. Educating customers about social engineering threats is also a key to mitigating these threats. And security analysts play an important part in promoting safe practices. For example, a big part of an analyst's job is testing systems and documenting best practices for others at an organization to follow.

Resources for more information

Here are two additional resources to review that will help you continue developing your understanding of social engineering trends and security practices:

- OUCH! is a free monthly newsletter from the SANS Institute that reports on social engineering trends and other security topics.
- Scamwatch is a resource for news and tools for recognizing, avoiding, and reporting social engineering scams.

Types of phishing

Phishing is one of the most common types of **social engineering**, which are manipulation techniques that exploit human error to gain private information, access, or valuables. Previously, you learned how **phishing** is the use of digital communications to trick people into revealing sensitive data or deploying malicious software.

Sometimes, phishing attacks appear to come from a trusted person or business. This can lead unsuspecting recipients into acting against their better judgment, causing them to break security procedures. In this reading, you'll learn about common phishing tactics used by attackers today.

The origins of phishing

Phishing has been around since the early days of the internet. It can be traced back to the 1990s. At the time, people across the world were coming online for the first time. As the internet became more accessible it began to attract the attention of malicious actors. These malicious actors realized that the internet gave them a level of anonymity to commit their crimes.

Early persuasion tactics

One of the earliest instances of phishing was aimed at a popular chat service called AOL Instant Messenger (AIM). Users of the service began receiving emails asking them to verify their accounts or provide personal billing information. The users were unaware that these messages were sent by malicious actors pretending to be service providers.

This was one of the first examples of mass phishing, which describes attacks that send malicious emails out to a large number of people, increasing the likelihood of baiting someone into the trap. During the AIM attacks, malicious actors carefully crafted emails that appeared to come directly from AOL. The messages used official logos, colors, and fonts to trick unsuspecting users into sharing their information and account details.

Attackers used the stolen information to create fraudulent AOL accounts they could use to carry out other crimes anonymously. AOL was forced to adapt their security policies to address these threats. The chat service began including messages on their platforms to warn users about phishing attacks.

How phishing has evolved

Phishing continued evolving at the turn of the century as businesses and newer technologies began entering the digital landscape. In the early 2000s, e-commerce and online payment systems started to become popular alternatives to traditional marketplaces. The introduction of online transactions presented new opportunities for attackers to commit crimes.

A number of techniques began to appear around this time period, many of which are still used today. There are five common types of phishing that every security analyst should know:

- **Email phishing** is a type of attack sent via email in which threat actors send messages pretending to be a trusted person or entity.
- **Smishing** is a type of phishing that uses Short Message Service (SMS), a technology that powers text messaging. Smishing covers all forms of text messaging services, including Apple's iMessages, WhatsApp, and other chat mediums on phones.
- **Vishing** refers to the use of voice calls or voice messages to trick targets into providing personal information over the phone.
- **Spear phishing** is a subset of email phishing in which specific people are purposefully targeted, such as the accountants of a small business.
- **Whaling** refers to a category of spear phishing attempts that are aimed at high-ranking executives in an organization.

Since the early days of phishing, email attacks remain the most common types that are used. While they were originally used to trick people into sharing access credentials and credit card information, email phishing became a popular method to infect computer systems and networks with malicious software.

In late 2003, attackers around the world created fraudulent websites that resembled businesses like eBay and PayPal™. Mass phishing campaigns to distribute malicious programs were also launched against e-commerce and banking sites.

Recent trends

Starting in the 2010s, attackers began to shift away from mass phishing attempts that relied on baiting unsuspecting people into a trap. Leveraging new technologies, criminals began carrying out what's known as targeted phishing attempts. Targeted phishing describes attacks that are sent to specific targets using highly customized methods to create a strong sense of familiarity.

A type of targeted phishing that evolved in the 2010s is angler phishing. **Angler phishing** is a technique where attackers impersonate customer service representatives on social media. This tactic evolved from people's tendency to complain about businesses online. Threat actors intercept complaints from places like message boards or comment sections and contact the angry customer via social media. Like the AIM attacks of the 1990s, they use fraudulent accounts that appear similar to those of actual businesses. They then trick the angry customers into sharing sensitive information with the promise of fixing their problem.

Resources for more information

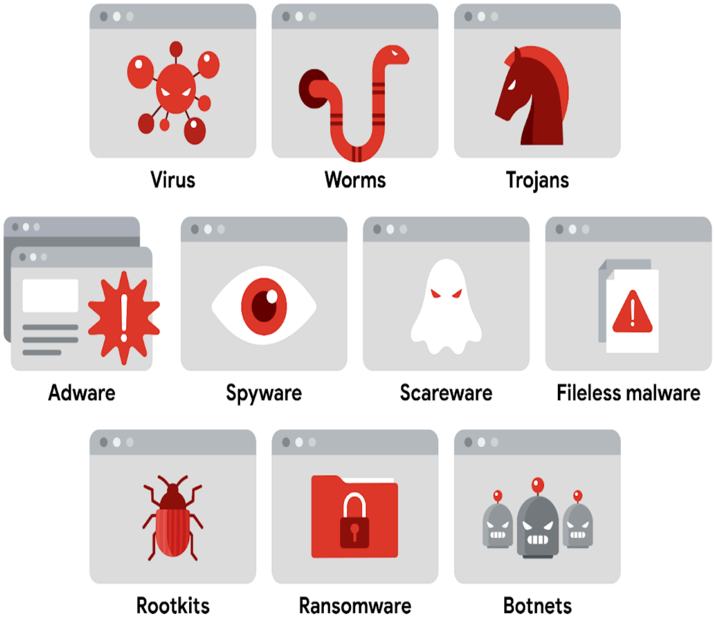
Staying up-to-date on phishing threats is one of the best things you can do to educate yourself and help your organization make smarter security decisions.

- Google's phishing quiz is a tool that you can use or share that illustrates just how difficult it can be to identify these attacks.
- Phishing.org reports on the latest phishing trends and shares free resources that can help reduce phishing attacks.
- The Anti-Phishing Working Group (APWG) is a non-profit group of multidisciplinary security experts that publishes a quarterly report on phishing trends.

Malware

An introduction to malware

Previously, you learned that **malware** is software designed to harm devices or networks. Since its first appearance on personal computers decades ago, malware has developed into a variety of strains. Being able to identify different types of malware and understand the ways in which they are spread will help you stay alert and be informed as a security professional.



Virus

A **virus** is malicious code written to interfere with computer operations and cause damage to data and software. This type of malware must be installed by the target user before it can spread itself and cause damage. One of the many ways that viruses are spread is through phishing campaigns where malicious links are hidden within links or attachments.

Worm

A **worm** is malware that can duplicate and spread itself across systems on its own. Similar to a virus, a worm must be installed by the target user and can also be spread with tactics like malicious email. Given a worm's ability to spread on its own, attackers sometimes target devices, drives, or files that have shared access over a network.

A well known example is the Blaster worm, also known as Lovesan, Lovsan, or MSBlast. In the early 2000s, this worm spread itself on computers running Windows XP and Windows 2000 operating systems. It would force devices into a continuous loop of shutting down and restarting. Although it did not damage the infected devices, it was able to spread itself to hundreds of thousands of users around the world. Many variants of the Blaster worm have been deployed since the original and can infect modern computers.

Note: Worms were very popular attacks in the mid 2000s but are less frequently used in recent years.

Trojan

A trojan, also called a **Trojan horse**, is malware that looks like a legitimate file or program. This characteristic relates to how trojans are spread. Similar to viruses, attackers deliver this type of malware hidden in file and application downloads. Attackers rely on tricking unsuspecting users into believing they're downloading a harmless file, when they're actually infecting their own device with malware that can be used to spy on them, grant access to other devices, and more.

Adware

Advertising-supported software, or **adware**, is a type of legitimate software that is sometimes used to display digital advertisements in applications. Software developers often use adware as a way to lower their production costs or to make their products free to the public—also known as freeware or shareware. In these instances, developers monetize their product through ad revenue rather than at the expense of their users.

Malicious adware falls into a sub-category of malware known as a **potentially unwanted application (PUA)**. A PUA is a type of unwanted software that is bundled in with legitimate programs which might display ads, cause device slowdown, or install other software. Attackers sometimes hide this type of malware in freeware with insecure design to monetize ads for themselves instead of the developer. This works even when the user has declined to receive ads.

Spyware

Spyware is malware that's used to gather and sell information without consent. It's also considered a PUA. Spyware is commonly hidden in *bundleware*, additional software that is sometimes packaged with other applications. PUAs like spyware have become a serious challenge in the open-source software development ecosystem. That's because developers tend to overlook how their software could be misused or abused by others.

Scareware

Another type of PUA is **scareware**. This type of malware employs tactics to frighten users into infecting their own device. Scareware tricks users by displaying fake warnings that appear to come from legitimate companies. Email and pop-ups are just a couple of ways scareware is spread. Both can be used to deliver phony warnings with false claims about the user's files or data being at risk.

Fileless malware

Fileless malware does not need to be installed by the user because it uses legitimate programs that are already installed to infect a computer. This type of infection resides in memory where the malware never touches the hard drive. This is unlike the other types of malware, which are stored within a file on disk. Instead, these stealthy infections get into the operating system or hide within trusted applications.

Pro tip: Fileless malware is detected by performing memory analysis, which requires experience with operating systems.

Rootkits

A **rootkit** is malware that provides remote, administrative access to a computer. Most attackers use rootkits to open a backdoor to systems, allowing them to install other forms of malware or to conduct network security attacks.

This kind of malware is often spread by a combination of two components: a dropper and a loader. A **dropper** is a type of malware that comes packed with malicious code which is delivered and installed onto a target system. For example, a dropper is often disguised as a legitimate file, such as a document, an image, or an executable to deceive its target into opening, or dropping it, onto their device. If the user opens the dropper program, its malicious code is executed and it hides itself on the target system.

Multi-staged malware attacks, where multiple packets of malicious code are deployed, commonly use a variation called a loader. A **loader** is a type of malware that downloads strains of malicious code from an external source and installs them onto a target system. Attackers might use loaders for different purposes, such as to set up another type of malware---a botnet.

Botnet

A **botnet**, short for "robot network," is a collection of computers infected by malware that are under the control of a single threat actor, known as the "bot-herder." Viruses, worms, and trojans are often used to spread the initial infection and turn the devices into a bot for the bot-herder. The attacker then uses file sharing, email, or social media application protocols to create new bots and grow the botnet. When a target unknowingly opens the malicious file, the computer, or bot, reports the information back to the bot-herder, who can execute commands on the infected computer.

Ransomware

Ransomware describes a malicious attack where threat actors encrypt an organization's data and demand payment to restore access. According to the Cybersecurity and Infrastructure Security Agency (CISA), ransomware crimes are on the rise and becoming increasingly sophisticated. Ransomware infections can cause significant damage to an organization and its customers. An example is the WannaCry attack that encrypts a victim's computer until a ransom payment of cryptocurrency is paid.

Web-based exploits

Prevent injection attacks

Previously, you learned that **Structured Query Language** (SQL) is a programming language used to create, interact with, and request information from a database. SQL is one of the most common programming languages used to interact with databases because it is widely supported by a range of database products.

As you might recall, malicious **SQL injection** is a type of attack that executes unexpected queries on a database. Threat actors perform SQL injections to modify, delete, or steal information from databases. A SQL injection is a common attack vector that is used to gain unauthorized access to web applications. Due to the language's popularity with developers, SQL injections are regularly listed in the OWASP® Top 10 because developers tend to focus on making their applications work correctly rather than protecting their products from injection.

In this reading, you'll learn about SQL queries and how they are used to request information from a database. You will also learn about the three classes of SQL injection attacks used to manipulate vulnerable queries. You will also learn ways to identify when websites are vulnerable and ways to address those gaps.

SQL queries

Every bit of information that's accessed online is stored in a database. A **database** is an organized collection of information or data in one place. A database can include data such as an organization's employee directory or customer payment methods. In SQL, database information is organized in tables. SQL is commonly used for retrieving, inserting, updating, or deleting information in tables using queries.

A *SQL query* is a request for data from a database. For example, a SQL query can request data from an organization's employee directory such as employee IDs, names, and job titles. A human resources application can accept an input that queries a SQL table to filter the data and locate a specific person. SQL injections can occur anywhere within a vulnerable application that can accept a SQL query.

Queries are usually initiated in places where users can input information into an application or a website via an input field. Input fields include features that accept text input such as login forms, search bars, or comment submission boxes. A SQL injection occurs when an attacker exploits input fields that aren't programmed to filter out unwanted text. SQL injections can be used to manipulate databases, steal sensitive data, or even take control of vulnerable applications.

SQL injection categories

There are three main categories of SQL injection:

- In-band
- Out-of-band
- Inferential

In the following sections, you'll learn that each type describes how a SQL injection is initiated and how it returns the results of the attack.

In-band SQL injection

In-band, or classic, SQL injection is the most common type. An in-band injection is one that uses the *same communication channel* to launch the attack and gather the results.

For example, this might occur in the search box of a retailer's website that lets customers find products to buy. If the search box is vulnerable to injection, an attacker could enter a malicious query that would be executed in the database, causing it to return sensitive information like user passwords. The data that's returned is displayed back in the search box where the attack was initiated.

Out-of-band SQL injection

An out-of-band injection is one that uses a *different communication channel* to launch the attack and gather the results.

For example, an attacker could use a malicious query to create a connection between a vulnerable website and a database they control. This separate channel would allow them to bypass any security controls that are in place on the website's server, allowing them to steal sensitive data

Note: Out-of-band injection attacks are very uncommon because they'll only work when certain features are enabled on the target server.

Inferential SQL injection

Inferential SQL injection occurs when an attacker is unable to directly see the results of their attack. Instead, they can interpret the results by analyzing the *behavior* of the system.

For example, an attacker might perform a SQL injection attack on the login form of a website that causes the system to respond with an error message. Although sensitive data is not returned, the attacker can figure out the database's structure based on the error. They can then use this information to craft attacks that will give them access to sensitive data or to take control of the system.

Injection Prevention

SQL queries are often programmed with the assumption that users will only input relevant information. For example, a login form that expects users to input their email address assumes the input will be formatted a certain way, such as *jdoe@domain.com*. Unfortunately, this isn't always the case.

A key to preventing SQL injection attacks is to *escape user inputs*—preventing someone from inserting any code that a program isn't expecting.

There are several ways to escape user inputs:

- **Prepared statements**: a coding technique that executes SQL statements before passing them on to a database
- **Input sanitization**: programming that removes user input which could be interpreted as code.
- **Input validation**: programming that ensures user input meets a system's expectations.

Using a combination of these techniques can help prevent SQL injection attacks. In the security field, you might need to work closely with application developers to address vulnerabilities that can lead to SQL injections. OWASP's SQL injection detection techniques is a useful resource if you're interested in investigating SQL injection vulnerabilities on your own.

Threat modeling

Traits of an effective threat model

Threat modeling is the process of identifying assets, their vulnerabilities, and how each is exposed to threats. It is a strategic approach that combines various security activities, such as vulnerability management, threat analysis, and incident response. Security teams commonly perform these exercises to ensure their systems are adequately protected. Another use of threat modeling is to proactively find ways of reducing risks to any system or business process.

Traditionally, threat modeling is associated with the field of application development. In this reading, you will learn about common threat modeling frameworks that are used to design software that can withstand attacks. You'll also learn about the growing need for application security and ways that you can participate.

Why application security matters

Applications have become an essential part of many organizations' success. For example, web-based applications allow customers from anywhere in the world to connect with businesses, their partners, and other customers.

Mobile applications have also changed the way people access the digital world. Smartphones are often the main way that data is exchanged between users and a business. The volume of data being processed by applications makes securing them a key to reducing risk for everyone who's connected.

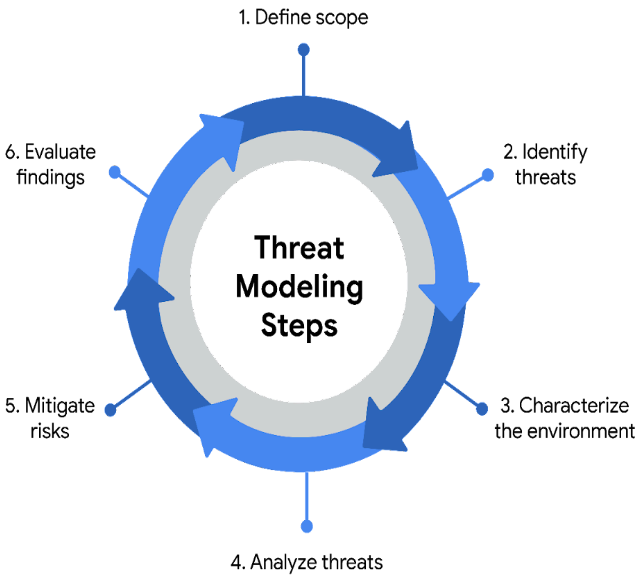
For example, say an application uses Java-based logging libraries with the Log4Shell vulnerability (CVE-2021-44228). If it's not patched, this vulnerability can allow remote code execution that an attacker can use to gain full access to your system from anywhere in the world. If exploited, a critical vulnerability like this can impact millions of devices.

Defending the application layer

Defending the application layer requires proper testing to uncover weaknesses that can lead to risk. Threat modeling is one of the primary ways to ensure that an application meets security requirements. A DevSecOps team, which stands for development, security, and operations, usually performs these analyses.

A typical threat modeling process is performed in a cycle:

- Define the scope
- Identify threats
- Characterize the environment
- Analyze threats
- Mitigate risks
- Evaluate findings



Ideally, threat modeling should be performed before, during, and after an application is developed. However, conducting a thorough software analysis takes time and resources. Everything from the application's architecture to its business purposes should be evaluated. As a result, a number of threat-modeling frameworks have been developed over the years to make the process smoother.

Note: Threat modeling should be incorporated at every stage of the software development lifecycle, or SDLC.

Common frameworks

When performing threat modeling, there are multiple methods that can be used, such as:

- STRIDE
- PASTA
- Trike
- VAST

Organizations might use any one of these to gather intelligence and make decisions to improve their security posture. Ultimately, the "right" model depends on the situation and the types of risks an application might face.

STRIDE

STRIDE is a threat-modeling framework developed by Microsoft. It's commonly used to identify vulnerabilities in six specific attack vectors. The acronym represents each of these vectors: spoofing, tampering, repudiation, information disclosure, denial of service, and elevation of privilege.

PASTA

The **Process of Attack Simulation and Threat Analysis** (PASTA) is a risk-centric threat modeling process developed by two OWASP leaders and supported by a cybersecurity firm called VerSprite. Its main focus is to discover evidence of viable threats and represent this information as a model. PASTA's evidence-based design can be applied when threat modeling an application or the environment that supports that application. Its seven stage process consists of various activities that incorporate relevant security artifacts of the environment, like vulnerability assessment reports.

Trike

Trike is an open source methodology and tool that takes a security-centric approach to threat modeling. It's commonly used to focus on security permissions, application use cases, privilege models, and other elements that support a secure environment.

VAST

The Visual, Agile, and Simple Threat (VAST) Modeling framework is part of an automated threat-modeling platform called ThreatModeler®. Many security teams opt to use VAST as a way of automating and streamlining their threat modeling assessments.

Participating in threat modeling

Threat modeling is often performed by experienced security professionals, but it's almost never done alone. This is especially true when it comes to securing applications. Programs are complex systems responsible for handling a lot of data and processing a variety of commands from users and other systems.

One of the keys to threat modeling is asking the right questions:

- What are we working on?
- What kinds of things can go wrong?
- What are we doing about it?
- Have we addressed everything?
- Did we do a good job?

It takes time and practice to learn how to work with things like data flow diagrams and attack trees. However, anyone can learn to be an effective threat modeler. Regardless of your level of experience, participating in one of these exercises always starts with simply asking the right questions.