Chapter 5:

Protection of Information Assets

Section One: Overview

Section Two: Content

Section One: Overview

DEFINITION

This chapter addresses the key components that ensure confidentiality, integrity and availability (CIA) of information assets. The design, implementation and monitoring of logical and physical access controls are explained. Network infrastructure security, environmental controls, and processes and procedures used to classify, enter, store, retrieve, transport and dispose of confidential information assets are covered. The methods and procedures followed by organizations are described, focusing on the auditor's role in evaluating these procedures for suitability and effectiveness.

OBJECTIVES

The objective of this domain is to ensure that the CISA candidate understands and can provide assurance that the enterprise's security policies, standards, procedures and controls ensure the confidentiality, integrity and availability of information assets.

This area represents 25 percent of the CISA examination (approximately 38 questions).

TASK AND KNOWLEDGE STATEMENTS

TASKS

There are six tasks within the protection of information assets domain:

T5.1 Evaluate the information security and privacy policies, standards and procedures for completeness, alignment with generally accepted practices and compliance with applicable external requirements.
T5.2 Evaluate the design, implementation, maintenance, monitoring and reporting of physical and environmental controls to determine whether information assets are adequately safeguarded.
T5.3 Evaluate the design, implementation, maintenance, monitoring and reporting of system and logical security controls to verify the confidentiality, integrity and availability of information.
T5.4 Evaluate the design, implementation and monitoring of the data classification processes and procedures for alignment with the organization's policies, standards, procedures and applicable external requirements.
T5.5 Evaluate the processes and procedures used to store, retrieve, transport and dispose of assets to determine whether information assets are adequately safeguarded.
T5.6 Evaluate the information security program to determine its effectiveness and alignment with the organization's strategies and objectives.

KNOWLEDGE STATEMENTS

The CISA candidate must have a good understanding of each of the topics or areas delineated by the knowledge statements. These statements are the basis for the exam.

There are 26 knowledge statements within the protection of information assets domain:

K5.1 Knowledge of generally accepted practices and applicable external requirements (e.g., laws, regulations) related to the protection of information assets
K5.2 Knowledge of privacy principles
K5.3 Knowledge of the techniques for the design, implementation, maintenance, monitoring and reporting of security controls
K5.4 Knowledge of physical and environmental controls and supporting practices related to the protection of information assets
K5.5 Knowledge of physical access controls for the identification, authentication and restriction of users to authorized facilities and hardware
K5.6 Knowledge of logical access controls for the identification, authentication and restriction of users to authorized functions and data
K5.7 Knowledge of the security controls related to hardware, system software (e.g., applications, operating systems) and database management systems.
K5.8 Knowledge of risk and controls associated with virtualization of systems
K5.9 Knowledge of risk and controls associated with the use of mobile and wireless devices, including personally owned devices (bring your own device [BYOD])
K5.10 Knowledge of voice communications security (e.g., PBX, Voice-over Internet Protocol [VoIP])
K5.11 Knowledge of network and Internet security devices, protocols and techniques
K5.12 Knowledge of the configuration, implementation, operation and maintenance of network security controls
K5.13 Knowledge of encryption-related techniques and their uses
K5.14 Knowledge of public key infrastructure (PKI) components and digital signature techniques
K5.15 Knowledge of risk and controls associated with peer-to-peer computing, instant messaging and web-based technologies (e.g., social networking, message boards, blogs, cloud computing)
K5.16 Knowledge of data classification standards related to the protection of information assets
K5.17 Knowledge of the processes and procedures used to store, retrieve, transport and dispose of confidential information assets
K5.18 Knowledge of risk and controls associated with data leakage
K5.19 Knowledge of security risk and controls related to end-user computing
K5.20 Knowledge of methods for implementing a security awareness program
K5.21 Knowledge of information system attack methods and techniques
K5.22 Knowledge of prevention and detection tools and control techniques
K5.23 Knowledge of security testing techniques (e.g., penetration testing, vulnerability scanning)
K5.24 Knowledge of processes related to monitoring and responding to security incidents (e.g., escalation procedures, emergency incident response team)
K5.25 Knowledge of the processes followed in forensics investigation and procedures in collection and preservation of the data and evidences (i.e., chain of custody).
K5.26 Knowledge of fraud risk factors related to the protection of information assets

Relationship of Task to Knowledge Statements

The task statements are what the CISA candidate is expected to know how to do. The knowledge statements delineate each of the areas in which the CISA candidate must have a good understanding in order to perform the tasks. The task and knowledge statements are mapped in **figure 5.1** insofar as it is possible to do so. Note that although there is often overlap, each task statement will generally map to several knowledge statements.

Figure 5.1—Task and Knowledge Statements Mapping

Task Statement	Knowledge Statements
T5.1 Evaluate the information security and privacy policies, standards and procedures for completeness, alignment with generally accepted practices and compliance with applicable external requirements.	K5.1 Knowledge of generally accepted practices and applicable external requirements (e.g., laws, regulations) related to the protection of information assets K5.2 Knowledge of privacy principles K5.3 Knowledge of the techniques for the design, implementation, maintenance, monitoring and reporting of security controls K5.4 Knowledge of physical and environmental controls and supporting practices related to the protection of information assets

	K5.5 Knowledge of physical access controls for the identification, authentication, and restriction of users to authorized facilities and hardware K5.6 Knowledge of logical access controls for the identification, authentication, and restriction of users to authorized functions and data K5.9 Knowledge of risk and controls associated with the use of mobile and wireless devices, including personally owned devices (bring your own device [BYOD]) K5.15 Knowledge of risk and controls associated with peer-to-peer computing, instant messaging, and web-based technologies (e.g., social networking, message boards, blogs, cloud computing) K5.16 Knowledge of data classification standards related to the protection of information assets K5.18 Knowledge of risk and controls associated with data leakage K5.19 Knowledge of security risk and controls related to end-user computing K5.20 Knowledge of methods for implementing a security awareness program K5.25 Knowledge of the processes followed in forensics investigation and procedures in collection and preservation of the data and evidences (i.e., chain of custody) K5.26 Knowledge of fraud risk factors related to the protection of information assets
T5.2 Evaluate the design, implementation, maintenance, monitoring and reporting of physical and environmental controls to determine whether information assets are adequately safeguarded.	K5.1 Knowledge of generally accepted practices and applicable external requirements (e.g., laws, regulations) related to the protection of information assets K5.2 Knowledge of privacy principles K5.3 Knowledge of the techniques for the design, implementation, maintenance, monitoring, and reporting of security controls K5.4 Knowledge of physical and environmental controls and supporting practices related to the protection of information assets K5.5 Knowledge of physical access controls for the identification, authentication, and restriction of users to authorized facilities and hardware K5.7 Knowledge of the security controls related to hardware, system software (e.g., applications, operating systems) and database management systems K5.10 Knowledge of voice communications security (e.g., PBX, Voice-over Internet Protocol [VoIP]) K5.17 Knowledge of the processes and procedures used to store, retrieve, transport and dispose of confidential information assets K5.18 Knowledge of risk and controls associated with data leakage K5.19 Knowledge of security risk and controls related to end-user computing K5.22 Knowledge of prevention and detection tools and control techniques K5.23 Knowledge of security testing techniques (e.g., penetration testing, vulnerability scanning) K5.26 Knowledge of fraud risk factors related to the protection of information assets
T5.3 Evaluate the design, implementation, maintenance, monitoring and reporting of system and logical security controls to verify the confidentiality, integrity and availability of information.	K5.1 Knowledge of generally accepted practices and applicable external requirements (e.g., laws, regulations) related to the protection of information assets K5.2 Knowledge of privacy principles K5.3 Knowledge of the techniques for the design, implementation, maintenance, monitoring and reporting of security controls K5.6 Knowledge of logical access controls for the identification, authentication and restriction of users to authorized functions and data K5.7 Knowledge of the security controls related to hardware, system software (e.g., applications, operating systems) and database management systems. K5.8 Knowledge of risk and controls associated with virtualization of systems K5.9 Knowledge of risk and controls associated with the use of mobile and wireless devices, including personally owned devices (bring your own device [BYOD]) K5.10 Knowledge of voice communications security (e.g., PBX, Voice-over Internet Protocol [VoIP]) K5.11 Knowledge of network and Internet security devices, protocols, and techniques K5.12 Knowledge of the configuration, implementation, operation, and maintenance of network security controls K5.13 Knowledge of encryption-related techniques and their uses K5.14 Knowledge of public key infrastructure (PKI) components and digital signature techniques K5.15 Knowledge of risk and controls associated with peer-to-peer computing, instant messaging and web-based technologies (e.g., social networking, message boards, blogs, cloud computing) K5.18 Knowledge of risk and controls associated with data leakage K5.19 Knowledge of security risk and controls related to end-user computing K5.21 Knowledge of information system attack methods and techniques K5.22 Knowledge of prevention and detection tools and control techniques K5.23 Knowledge of security testing techniques (e.g., penetration testing, vulnerability scanning) K5.26 Knowledge of fraud risk factors related to the protection of information assets
T5.4 Evaluate the design, implementation and monitoring of the data classification processes and procedures for alignment with the organization's policies, standards, procedures and applicable external requirements.	K5.1 Knowledge of generally accepted practices and applicable external requirements (e.g., laws, regulations) related to the protection of information assets K5.2 Knowledge of privacy principles K5.3 Knowledge of the techniques for the design, implementation, maintenance, monitoring and reporting of security controls K5.9 Knowledge of risk and controls associated with the use of mobile & wireless devices, including personally owned devices (bring your own device [BYOD]) K5.13 Knowledge of encryption-related techniques and their uses K5.14 Knowledge of public key infrastructure (PKI) components and digital signature techniques K5.15 Knowledge of risk and controls associated with peer-to-peer computing, instant messaging and web-based technologies (e.g., social networking, message boards, blogs, cloud computing) K5.16 Knowledge of data classification standards related to the protection of information assets K5.18 Knowledge of risk and controls associated with data leakage K5.19 Knowledge of security risk and controls related to end-user computing K5.25 Knowledge of the processes followed in forensics investigation and procedures in collection and preservation of the data and evidences (i.e., chain of custody)
T5.5 Evaluate the processes and procedures used to store, retrieve, transport and dispose of assets to determine whether information assets are adequately safeguarded.	K5.1 Knowledge of generally accepted practices and applicable external requirements (e.g., laws, regulations) related to the protection of information assets K5.2 Knowledge of privacy principles K5.3 Knowledge of the techniques for the design, implementation, maintenance, monitoring and reporting of security controls K5.4 Knowledge of physical and environmental controls and supporting practices related to the protection of information assets K5.5 Knowledge of physical access controls for the identification, authentication and restriction of users to authorized facilities and hardware

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T5.6 Evaluate the information security program to determine its effectiveness and alignment with the organization's strategies and objectives.	K5.1 Knowledge of generally accepted practices and applicable external requirements (e.g., laws, regulations) related to the protection of information assets K5.2 Knowledge of privacy principles K5.3 Knowledge of the techniques for the design, implementation, maintenance, monitoring and reporting of security controls K5.4 Knowledge of physical and environmental controls and supporting practices related to the protection of information assets K5.5 Knowledge of physical access controls for the identification, authentication and restriction of users to authorized facilities and hardware K5.6 Knowledge of logical access controls for the identification, authentication and restriction of users to authorized functions and data K5.7 Knowledge of the security controls related to hardware, system software (e.g., applications, operating systems) and database management systems K5.8 Knowledge of risk and controls associated with virtualization of systems K5.9 Knowledge of risk and controls associated with the use of mobile and wireless devices, including personally owned devices (bring your own device [BYOD]) K5.11 Knowledge of network and Internet security devices, protocols and techniques K5.12 Knowledge of the configuration, implementation, operation and maintenance of network security controls K5.13 Knowledge of encryption-related techniques and their uses K5.14 Knowledge of public key infrastructure (PKI) components and digital signature techniques K5.15 Knowledge of risk and controls associated with peer-to-peer computing, instant messaging and web-based technologies (e.g., social networking, message boards, blogs, cloud computing) K5.18 Knowledge of risk and controls associated with data leakage K5.19 Knowledge of security risk and controls related to end-user computing K5.20 Knowledge of methods for implementing a security awareness program K5.21 Knowledge of information system attack methods and techniques K5.22 Knowledge of prevention and detection tools and control techniques K5.23 Knowledge of security testing techniques (e.g., penetration testing, vulnerability scanning) K5.24 Knowledge of processes related to monitoring and responding to security incidents (e.g., escalation procedures, emergency incident response team) K5.25 Knowledge of the processes followed in forensics investigation and procedures in collection and preservation of the data and evidences (i.e., chain of custody) K5.26 Knowledge of fraud risk factors related to the protection of information assets

Knowledge Statement Reference Guide

Each knowledge statement is explained in terms of underlying concepts and relevance of the knowledge statement to the IS auditor. It is essential that the exam candidate understand the concepts. The knowledge statements are what the IS auditor must know in order to accomplish the tasks. Consequently, only the knowledge statements are detailed in this section.

The sections identified in K5.1 through K5.26 are described in greater detail in section two of this chapter.

K5.1 Knowledge of generally accepted practices and applicable external requirements (e.g., laws, regulations) related to the protection of information assets

Explanation	Key Concepts	Reference in Manual
There are a number of generally accepted practices related to the protection of information assets. The IS auditor should be aware of these practices. For example: • Security needs to be aligned with business objectives • Security should be led by senior management setting the "tone at the top" • Responsibilities for the protection of assets should be defined • Policies and procedures should be in place to: – Ensure the continued availability of information systems. – Ensure the integrity of information stored on its computer systems and while the information is in transit. – Preserve the confidentiality of sensitive data while stored and in transit. – Ensure compliance with applicable laws, regulations and standards. • Monitoring should be in place to ensure compliance with internal policies and any external requirements • A risk management process should be in place	Understanding the elements of information security management	5.2.1 Key Elements of Information Security Management 5.2.9 Critical Success Factors to Information Security Management
	Ability to assess the classification of information assets within an information security context	5.2.3 Classification of Information Assets

K5.2 Knowledge of privacy principles

Explanation	Key Concepts	Reference in Manual
IS auditors should be able to ensure adherence to trust and obligation requirements for any information relating to an identified or identifiable individual (i.e., data subject) in accordance with the applicable privacy policy, privacy laws and/or regulations.	Understanding of privacy principles	5.2.8 Privacy Principles and the Role of IS Auditors
	Knowledge of privacy laws and regulations	
	Understand how compliance is assured	

K5.3 Knowledge of the techniques for the design, implementation, maintenance, monitoring and reporting of security controls

Explanation	Key Concepts	Reference in Manual
The IS auditor should understand the different types of internal controls and their applicability. The design, implementation and monitoring of security should be aligned with business goals and objectives. The focus should be on those items that, if their security were compromised, would impact the organization in tangible (if not always quantifiable) ways. Controls generally incur a business cost, either directly or in their effect on business activities, and organizations should ensure that the cost of control does not materially exceed the business risk. The primary focus should be to ensure that risk which would have a material adverse impact on business is appropriately managed.	Understand the different types of controls (preventive, detective and corrective) and when to apply them	1.4.2 Internal Controls 5.2.5 Information Security Control Design 5.2.9 Critical Success Factors to Information Security Management
	Ability to assess the classification of information assets within an information security context	5.2.3 Classification of Information Assets
	Understanding information security as it applies to key network infrastructure components	5.4 Network Infrastructure Security

K5.4 Knowledge of physical and environmental controls and supporting practices related to the protection of information assets

Explanation	Key Concepts	Reference in Manual
Certain natural and manmade events have the ability to do great damage to an enterprise's information systems and business processes. Most data centers have mechanisms to prevent, detect or mitigate the impact of these threats. However, it is important that the readiness and sufficiency of these controls be periodically tested by management to ensure that they will function as intended. The IS auditor should understand the nature of these controls and how to ensure that they are functioning properly and are adequate to protect the enterprise. Environmental controls generally include fire and smoke detectors, fire suppression systems, water detectors, and temperature and humidity controls. The IS auditor should know the relative merits of different fire suppression systems and in what circumstances one type is more appropriate than another.	Understanding the common types of environmental controls and good practices for their deployment and periodic testing	5.7 Environmental Exposures and Controls

K5.5 Knowledge of physical access controls for the identification, authentication and restriction of users to authorized facilities and hardware

Explanation	Key Concepts	Reference in Manual
Physical security weaknesses can result in financial loss, legal repercussions or loss of credibility or competitive edge. Thus, information assets must be protected against physical attacks, such as vandalism and theft, through controls that restrict access to sensitive areas containing computer equipment or confidential data files. Such controls usually employ the use of access door locks that require the use of a password, key, token or biometric authentication of the person attempting entry. In high-security areas, access may require authentication through multiple means and the use of strong security measures such as the air-lock type or mantrap entrance. The IS auditor should understand the nature of physical controls and the ways in which they can be circumvented and the concept of "security boundary" to establish where such devices should be placed and how effective they must be.	Understanding physical access controls and their potential for circumvention	5.8 Physical Access Exposures and Controls

K5.6 Knowledge of logical access controls for the identification, authentication and restriction of users to authorized functions and data

Explanation	Key Concepts	Reference in Manual
Logical access controls are used to manage and protect information assets. Controls enact and substantiate policies and procedures designed by management to protect information assets, and controls are designed to reduce risk to a level acceptable to an enterprise. Controls exist at both the operating system level and the application level, so it is important to understand logical access controls as they apply to systems that may reside on multiple operating system platforms and involve more than one application system or authentication point. Logical security is often determined based on the job function of users. The success of logical access controls is tied to the strength of the authentication method (e.g., strong passwords). All user access to systems and data should be appropriately authorized and commensurate with the role of the individual. Authorization generally takes the form of signatures (physical or electronic) of relevant management. The strength of the authentication is proportional to the quality of the method used; strong authentication may include dual or multifactor authentication using user ID, password, tokens and biometrics.	Understanding the key elements of logical access controls	5.3 Logical Access

K5.7 Knowledge of the security controls related to hardware, system software (e.g., applications, operating systems) and database management systems

Explanation	Key Concepts	Reference in Manual
Access control software utilizes both identification and authentication (I&A): Once authenticated, the system or application then restricts access based on the specific role of the user. I&A is the process by which the system obtains the identity from a user and the credentials needed to authenticate the identity, and then I&A validates both pieces of information. I&A is a critical building block of computer security because it is needed for most types of access control and is necessary for establishing user accountability. For most systems, I&A is the first line of defense because it prevents unauthorized access (or unauthorized processes) to a computer system or an information asset. Logical access can be implemented in various ways. The IS auditor should be aware of the strengths and weaknesses of various architectures such as single sign-on (SSO), in which a single authentication will enable access to all authorized applications, identity management, multifactor authentication, etc. The IS auditor must understand the risk associated with the different architectures and how they may be addressed. For example, SSO may enable unauthorized access to applications and data if a single password is compromised. If this risk is considered manageable, it should drive the implementation of multifactor authentication.	Understanding good practices as they apply to identification and authentication	4.4 Information Systems Hardware 4.5.1 Operating Systems 4.5.5 Database Management Systems 5.3.5 Identification and Authentication

K5.8 Knowledge of risk and controls associated with virtualization of systems

Explanation	Key Concepts	Reference in Manual
Virtualization provides an enterprise with a significant opportunity to increase efficiency and to decrease costs in its IT operations. However, virtualization also introduces additional risk. IS auditors need to understand the advantages and disadvantages of virtualization and determine whether the enterprise has considered the applicable risk in its decision to adopt, implement and maintain this technology. At a high level, virtualization allows multiple operating systems (OSs), or guests, to coexist on the same physical server, or host, in isolation of one another. Virtualization creates a layer between the hardware and the guest OSs to manage shared processing and memory resources on the host. A management console often provides administrative access to manage the virtualized system. Although virtualization offers significant advantages, these advantages come with risk that an enterprise must manage effectively. Because the host in a virtualized environment represents a potential single point of failure within the system, a successful attack on the host could result in a compromise that is larger in both scope and impact.	Understanding the risk associated with virtualization	5.4.1 LAN Security

K5.9 Knowledge of risk and controls associated with the use of mobile and wireless devices, including personally owned devices (bring your own device [BYOD])

Explanation	Key Concepts	Reference in Manual
Portable and wireless devices present a ubiquitous threat to an enterprise's information assets and must be properly controlled. Policies and procedures and additional protection mechanisms must be put into place to ensure that data are protected to a greater extent on portable devices because such devices will most likely operate in environments in which physical controls are lacking or nonexistent. Most mobile devices, including tablets, smartphones, etc., are easily lost or stolen and, thus, require the use of encryption technologies and strong authentication. It also may be necessary to classify some data as inappropriate for storage on a mobile device. The IS auditor should understand that all such media and devices, including personal music (MP3) devices, can also be used by an individual to steal both data and programs for personal use or gain.	Understanding good practices for securing data on mobile computing devices	4.4.1 Computer Hardware Components and Architectures 4.6.6 Application of the OSI Model in Network Architectures 5.9 Mobile Computing

K5.10 Knowledge of voice communications security (e.g., PBX, Voice-over Internet Protocol [VoIP])

Explanation	Key Concepts	Reference in Manual
The increasing complexity and convergence of voice and data communications introduces additional risk that must be taken into account by the IS auditor. VoIP and PBX environments involve security risk (both within and outside the enterprise) that must be addressed to ensure the security and reliability of voice communications. The IS auditor should have enough understanding of these concepts to establish the business risk and identify appropriate controls.	Understanding the risk and associated controls related to voice communications and the impact of VoIP on overall network security	5.4.7 Voice-over IP 5.4.8 Private Branch Exchange

K5.11 Knowledge of network and Internet security devices, protocols and techniques

Explanation	Key Concepts	Reference in Manual
Application and evaluation of technologies to reduce risk and secure data are dependent on proper understanding of security devices, their functions and protocols used in delivering functionality. An enterprise implements specific applications of cryptographic systems to ensure confidentiality of important data. There are a number of cryptographic protocols that provide secure communications on the Internet. Additionally, the security landscape is filled with technologies and solutions to address a myriad of needs. Solutions include firewalls, intrusion detection and prevention devices, proxy devices, web filters, antivirus and antispam filters, data leak protection functionality, identity and access control mechanisms, secured remote access, and wireless security. Understanding the solution's function and its application to the underlying infrastructure requires knowledge of the infrastructure itself and the protocols in use. The IS auditor is not expected to possess a detailed, technical knowledge but rather a general understanding of the concepts, how they may be implemented and what business risk may be involved.	Understanding good practices for the implementation of encryption	5.4.5 Encryption
	Understanding the use and application of security devices and methods for securing data	4.6 IS Network Infrastructure 5.3.5 Identification and Authentication 5.4 Network Infrastructure Security

K5.12 Knowledge of the configuration, implementation, operation and maintenance of network security controls

Explanation	Key Concepts	Reference in Manual
Enterprises can effectively prevent and detect most attacks on their networks by employing perimeter security controls. Firewalls and intrusion detection systems (IDSs) provide protection and critical alert information at borders between trusted and untrusted networks. The proper implementation and maintenance of firewalls and IDSs is critical to a successful, in-depth security program. The IS auditor must understand the level of intruder detection provided by the different possible locations of the IDS and the importance of policies and procedures to determine the action required by security and technical staff when an intruder is reported.	Understanding network security threats and knowing the most appropriate controls to mitigate these threats	5.4.4 Internet Threats and Security

K5.13 Knowledge of encryption-related techniques and their uses

Explanation	Key Concepts	Reference in Manual
One of the best ways to protect the confidentiality of information is through the use of encryption. Effective encryption systems depend on: • Algorithm strength, secrecy and difficulty of compromising a key • The nonexistence of back doors by which an encrypted file can be decrypted without knowing the key • The inability to decrypt an entire ciphertext message if the way a portion of it decrypts is known (called a known-text attack) • Properties of the plaintext being known by a perpetrator Although the IS auditor is not expected to be an expert in how these algorithms are designed, the auditor should be able to understand how these techniques are used and the relative advantages and disadvantages of each.	Understanding the fundamentals of encryption techniques and the relative advantages and disadvantages of each	5.4.5 Encryption

K5.14 Knowledge of public key infrastructure (PKI) components and digital signature techniques

Explanation	Key Concepts	Reference in Manual
Encryption is the process of converting a plaintext message into a secure-coded form of text, called ciphertext, which cannot be understood without converting back via decryption (the reverse process) to plaintext. PKIs use encryption to facilitate the following: • Protect data in transit over networks from unauthorized interception and manipulation • Protect information stored on computers from unauthorized viewing and manipulation • Deter and detect accidental or intentional alterations of data • Verify authenticity of a transaction or document (e.g., when transmitted over a web-based connection in online banking, share dealing, etc.) • Protect data in such situations from unauthorized disclosure The IS auditor is not expected to have a detailed comprehension of cryptography but should understand the relationships between types of encryption (symmetric and asymmetric) and their respective algorithms (e.g., DES3, RSA) and the basic concepts and components of PKI in terms of business use. For example, if a message is encrypted with a private key, it provides authentication of the sender rather than privacy. Understanding the business use of digital signatures is also expected, especially its use in providing nonrepudiation of and replay protection to messages.	Understanding the key components of PKIs and how they are controlled	5.4.5 Encryption

K5.15 Knowledge of risk and controls associated with peer-to-peer computing, instant messaging and web-based technologies (e.g., social networking, message boards, blogs, cloud computing)

Explanation	Key Concepts	Reference in Manual
Peer-to-peer computing, instant messaging and web-based technologies (e.g., social networking, blogs) are technologies that introduce a unique type of risk to the enterprise. Information posted on social networking sites may inadvertently disclose confidential nonpublic information that may expose an organization (causing it to lose its competitive advantage) or may violate regulatory requirements such as financial securities or privacy laws. Peer-to-peer computing is inherently insecure, as it provides direct access to systems bypassing the network security controls, and may lead to the introduction of malicious code into an otherwise secure environment. The IS auditor should be familiar with the service models and deployment models available with cloud computing. The IS auditor should also be familiar with the key risk and controls associated with cloud computing including transborder issues, data disposal, exit strategy, etc.	Understanding risk and controls associated with peer-to-peer computing, instant messaging and web-based technologies (e.g., social networking, message boards, blogs)	5.10 Peer-to-peer Computing 5.11 Instant Messaging 5.12 Social Media
	Understanding risk and controls associated with cloud computing	2.9.2 Sourcing Practices 5.13 Cloud Computing

K5.16 Knowledge of data classification standards related to the protection of information assets

Explanation	Key Concepts	Reference in Manual
Information assets have varying degrees of sensitivity and criticality in meeting business objectives. Important first steps to data classification are discovery, inventory and risk assessment. The risk assessment should take into consideration that the value of the asset is directly proportional to its role in the strategy of the enterprise. Once this is accomplished, data classification can then be put into use. By assigning classes or levels of sensitivity and criticality to information resources and establishing specific security rules for each class, enterprises can define the level of access control and the retention time and destruction requirements that should be applied to each information asset. Data are, therefore, classified and protected in accordance with the degree of sensitivity and criticality assigned to them. The IS auditor should understand the process of classification and the interrelationship between data classification and the need for inventorying information assets and assigning responsibility to data owners. Data owner responsibilities should be clearly identified, documented and implemented.	Understanding data classification schemes and the need for assignment of data owners	4.3 IT Asset Management 5.2.3 Classification of Information Assets

K5.17 Knowledge of the processes and procedures used to store, retrieve, transport and dispose of confidential information assets

Explanation	Key Concepts	Reference in Manual
Confidential information assets are vulnerable during storage, retrieval and transport and must be disposed of properly. Management should define and implement procedures to prevent unauthorized access to or loss of sensitive information and software from computers, disks and other equipment or media when they are stored, transported or transmitted and during processing, retrieval and output. The IS auditor should also understand the need for correct disposal of information (and media) to ensure that no unauthorized person gains access to the information by restoration or recreation.	Understanding good practices for protecting information during storage, retrieval, transport and disposal	4.8.6 Backup and Restoration 5.3.7 Storing, Retrieving, Transporting and Disposing of Confidential Information

K5.18 Knowledge of risk and controls associated with data leakage

Explanation	Key Concepts	Reference in Manual
Data leakage is the risk that sensitive information may be inadvertently made public. It can occur in a variety of ways—from job postings that list the specific software and network devices with which applicants should have experience, to system administrators posting questions on technical web sites that include postings with specific details on the firewall or database version they are running and the IP addresses they are trying to connect. Other examples include posting organization charts and strategic plans on externally accessible web sites. At first glance, one would think that no enterprise would ever think of doing this, and yet there are governmental agencies and nonprofit organizations that have placed their organizations at risk in their zeal to be transparent. Data classification policies, security awareness training and periodic audits for data leakage are elements that the IS auditor will want to ensure are in place. The IS auditor should also be familiar with data leakage prevention (DLP) tools capabilities and risk.	Understanding how data leakage can occur and the methods for limiting data leakage	4.3 IT Asset Management 5.2.3 Classification of Information Assets 5.10 Peer-to-peer Computing 5.11 Instant Messaging 5.12 Social Media 5.14 Data Leakage

K5.19 Knowledge of security risk and controls related to end-user computing

Explanation	Key Concepts	Reference in Manual
It is necessary for the IS auditor to understand the security risk and controls associated with end-user computing (e.g. Microsoft® Excel, Access, etc.). This IS auditor should understand that these tools can be used to create key applications that are relied upon by the organization but not controlled by the IT department. This, in turn, means that they may not be secured, have logging enabled or sensitive data encrypted.	Understanding the security risk and controls associated with end-user computing	4.5.9 End-user Computing 5.15 End-user Computing Security Risk and Controls

K5.20 Knowledge of methods for implementing a security awareness program

Explanation	Key Concepts	Reference in Manual
The IS auditor should understand that risk in using IT systems is not only addressed through technical mechanisms. Security awareness programs can reduce risk through education. Security awareness programs should be aligned to the needs of the organization and focus on common user security concerns. Security awareness programs should also be tailored to specific groups. Security awareness programs can also be delivered through different media.	Understand the need for security awareness programs and the need to tailor them for organizational and user needs	5.2.1 Key Elements of Information Security Management
	Understand the different ways to implement security awareness programs	5.2.9 Critical Success Factors to Information Security Management

K5.21 Knowledge of information system attack methods and techniques

Explanation	Key Concepts	Reference in Manual
Risk arises from vulnerabilities (whether technical or human) within an environment. Attack techniques exploit those vulnerabilities and may originate either within or outside the enterprise. Computer attacks can result in proprietary or confidential data being stolen or modified, loss of customer confidence and market share, embarrassment to management, and legal actions against an enterprise. Understanding the methods, techniques and exploits used to compromise an environment provides the IS auditor with a more complete context for understanding the risk that an enterprise faces. Taking these techniques into consideration and understanding that they can be launched from any location allow for more thorough evaluations, ultimately providing a more secure environment. The IS auditor should understand enough of these attack types to recognize their risk to the business and how they should be addressed by appropriate controls. The IS auditor should understand the concept of social engineering as these attacks can circumvent the strongest technical security. The only effective control is regular user education.	Understanding general issues regarding attack methods and computer crime	5.2.12 Computer Crime Issues and Exposures
	Ability to identify controls that are most effective in preventing or detecting attacks involving social engineering, wireless access and threats originating from the Internet	5.4.3 Wireless Security Threats and Risk Mitigation 5.4.4 Internet Threats and Security

K5.22 Knowledge of prevention and detection tools and control techniques

Explanation	Key Concepts	Reference in Manual
Computer viruses and other malware continue to emerge at increasing rates and levels of sophistication and present significant threats to individuals and enterprises. Layered tools should be implemented and distributed throughout the environment to mitigate the ability of this malware to adversely impact the enterprise. Antivirus and antispam software are necessary and critical components of an enterprise's security program, providing a mechanism to detect, contain and notify whenever malicious code is detected. It is essential that the IS auditor understand not only the need for the implementation of anti-malware software, but that it should be constantly updated to ensure that it can detect and eradicate the latest attacks detected by the solutions providers.	Understanding the threats posed by malicious code and the good practices for mitigating these threats	5.4.4 Internet Threats and Security 5.4.6 Malware

K5.23 Knowledge of security testing techniques (e.g., penetration testing, vulnerability scanning)

Explanation	Key Concepts	Reference in Manual
Tools are available to assess the effectiveness of network infrastructure security. These tools permit identification of real-time risk to an information processing environment and corrective actions taken to mitigate the risk. Such risk often involves the failure to stay updated on patch management for operating systems or the misconfiguration of security settings. Assessment tools (whether open source or commercially produced) can quickly identify weaknesses that would have taken hundreds of hours to identify manually. The IS auditor should also be aware that security testing may be carried out by an approved third party (e.g., a company specializing in penetration testing).	Understanding how assessment tools can be used to identify vulnerabilities within the network infrastructure so that corrective actions can be taken to remediate risk	5.6 Auditing Network Infrastructure Security

K5.24 Knowledge of processes related to monitoring and responding to security incidents (e.g., escalation procedures, emergency incident response team)

Explanation	Key Concepts	Reference in Manual
A formal incident response capability should be established to minimize damage from security incidents, recover in a timely and controlled manner and learn from such incidents. The organization and management of an incident response capability should be coordinated or centralized with the establishment of key roles and responsibilities. While security management will typically be responsible for monitoring and investigating events and be the origination point for escalation procedures, other functions must be involved to ensure a proper response. Those functions must have well-defined and communicated processes in place that are tested periodically. These processes may include communications with executive management, forensic evidence collection, incident response and procedures to handle legal issues and public relations. The IS auditor should be aware of the need for enterprises to establish procedures to identify, report, record, respond, analyze, escalate and monitor security incidents.	Understanding the roles and responsibilities for incident response and the order and purpose of the key phases	5.2.13 Security Incident Handling and Response

K5.25 Knowledge of the processes followed in forensics investigation and procedures in collection and preservation of the data and evidences (i.e., chain of custody)

Explanation	Key Concepts	Reference in Manual
As electronic evidence is more dynamic than hard copy documents, security measures should be used to preserve the integrity of evidence collected and provide assurance that the evidence has not been altered in any way. In fraud investigations or legal proceedings, maintaining the integrity of evidence throughout the evidence life cycle may be referred to as the chain of custody when the evidence is classified as forensic. The IS auditor is expected to be aware of, rather than be a participant in, such specific evidence collection.	Factors to consider in collection, protection and chain of custody of evidence	5.5.4 Investigation Techniques

K5.26 Knowledge of fraud risk factors related to the protection of information assets

Explanation	Key Concepts	Reference in Manual
The IS auditor should be aware that the risk of fraud is increased where there is a perceived opportunity. An opportunity will be perceived where poor controls are in place. If an information asset is not properly protected it is more susceptible to fraud.	Relationship between controls and fraud risk	5.2.4 Fraud Risk Factors

SUGGESTED RESOURCES FOR FURTHER STUDY

Cendrowski, Harry; James P. Martin; Louis W. Petro; *The Handbook of Fraud Deterrence*, John Wiley & Sons Inc., USA, 2006

Davis, Chris; Mike Schiller; Kevin Wheeler; *IT Auditing: Using Controls to Protect Information Assets, 2nd Edition*, McGraw Hill, USA, 2011

Dubin, Joel; *The Little Black Book of Computer Security, 2nd Edition*, Penton Media Inc., USA, 2008

Harris, Shon; Allen Harper; Chris Eagle; Jonathan Ness; Gideon Lenkey; Terron Williams; *Gray Hat Hacking: The Ethical Hackers Handbook, 3rd Edition*, McGraw Hill, USA, 2011

ISACA, *The Business Model for Information Security*, USA, 2010

ISACA, *COBIT 5 for Information Security*, USA 2012, *www.isaca.org/cobit*

ISACA, *Security Considerations for Cloud Computing*, USA, 2013

International Organization for Standardization (ISO); *ISO/IEC 27002:2013: Information technology—Security techniques—Code of practice for information security controls*, Switzerland, 2013

Jaquith, Andrew; *Security Metrics: Replacing Fear, Uncertainty and Doubt*, Addison Wesley, USA, 2007

Killmeyer, Jan; *Information Security Architecture: An Integrated Approach to Security in the Organization, 2nd Edition*, Auerbach Publications, USA, 2006

Marcella Jr., Albert J.; Doug Menendez; *Cyber Forensics: A Field Manual for Collecting, Examining and Preserving Evidence of Computer Crime, 2nd Edition*, Auerbach Publications, USA, 2007

McClure, Stuart; Joel Scambray; George Kurtz; *Hacking Exposed 7: Network Security Secrets & Solutions*, McGraw Hill, USA, 2012

Natan, Ron Ben; *Implementing Database Security and Auditing*, Elsevier Digital Press, USA, 2005

Peltier, Thomas R.; *Information Security Risk Analysis, 3rd Edition*, Auerbach Publications, USA, 2010

Stamp, Mark; *Information Security: Principles and Practice, 2nd Edition*, John Wiley & Sons, USA, 2011

Stanley, Richard A.; *Managing Risk in the Wireless Environment: Security*, Audit and Control Issues, ISACA, USA, 2005

Vacca, John; *Biometric Technologies and Verification Systems*, Butterworth-Heinemann, USA, 2007

Wells, Joseph T.; *Fraud Casebook, Lessons From the Bad Side of Business*, John Wiley & Sons Inc., USA, 2007

Note: Publications in bold are stocked in the ISACA Bookstore.

SELF-ASSESSMENT QUESTIONS

CISA self-assessment questions support the content in this manual and provide an understanding of the type and structure of questions that have typically appeared on the exam. Questions are written in a multiple-choice format and designed for one best answer. Each question has a stem (question) and four options (answer choices). The stem may be written in the form of a question or an incomplete statement. In some instances, a scenario or a description problem may also be included. These questions normally include a description of a situation and require the candidate to answer two or more questions based on the information provided. Many times a question will require the candidate to choose the **MOST** likely or **BEST** answer among the options provided.

In each case, the candidate must read the question carefully, eliminate known incorrect answers and then make the best choice possible. Knowing the format in which questions are asked, and how to study and gain knowledge of what will be tested, will help the candidate correctly answer the questions.

5-1 An IS auditor reviewing the configuration of a signature-based intrusion detection system (IDS) would be **MOST** concerned if which of the following is discovered?

A. Auto-update is turned off.
B. Scanning for application vulnerabilities is disabled.
C. Analysis of encrypted data packets is disabled.
D. The IDS is placed between the demilitarized zone (DMZ) and the firewall.

5-2 Which of the following **BEST** provides access control to payroll data being processed on a local server?

A. Logging access to personal information
B. Using separate passwords for sensitive transactions
C. Using software that restricts access rules to authorized staff
D. Restricting system access to business hours

5-3 An IS auditor has just completed a review of an organization that has a mainframe computer and two database servers where all production data reside. Which of the following weaknesses would be considered the **MOST** serious?

A. The security officer also serves as the database administrator.
B. Password controls are not administered over the two database servers.
C. There is no business continuity plan for the mainframe system's noncritical applications.
D. Most local area networks (LANs) do not back up file-server-fixed disks regularly.

5-4 An organization is proposing to install a single sign-on facility giving access to all systems. The organization should be aware that:

A. maximum unauthorized access would be possible if a password is disclosed.
B. user access rights would be restricted by the additional security parameters.
C. the security administrator's workload would increase.
D. user access rights would be increased.

5-5 When reviewing an implementation of a Voice-over Internet Protocol (VoIP) system over a corporate wide area network (WAN), an IS auditor should expect to find:

A. an integrated services digital network (ISDN) data link.
B. traffic engineering.
C. wired equivalent privacy (WEP) encryption of data.
D. analog phone terminals.

5-6 An insurance company is using public cloud computing for one of its critical applications to reduce costs. Which of the following would be of **MOST** concern to the IS auditor?

A. The inability to recover the service in a major technical failure scenario
B. The data in the shared environment being accessed by other companies
C. The service provider not including investigative support for incidents
D. The long-term viability of the service if the provider goes out of business

5-7 Which of the following **BEST** determines whether complete encryption and authentication protocols for protecting information while being transmitted exist?

A. A digital signature with RSA has been implemented.
B. Work is being done in tunnel mode with the nested services of authentication header (AH) and encapsulating security payload (ESP).
C. Digital certificates with RSA are being used.
D. Work is being done in transport mode with the nested services of AH and ESP.

5-8 Which of the following concerns about the security of an electronic message would be addressed by digital signatures?

A. Unauthorized reading
B. Theft
C. Unauthorized copying
D. Alteration

5-9 Which of the following characterizes a distributed denial-of-service (DDoS) attack?

A. Central initiation of intermediary computers to direct simultaneous spurious message traffic at a specified target site
B. Local initiation of intermediary computers to direct simultaneous spurious message traffic at a specified target site
C. Central initiation of a primary computer to direct simultaneous spurious message traffic at multiple target sites
D. Local initiation of intermediary computers to direct staggered spurious message traffic at a specified target site

5-10 Which of the following is the **MOST** effective preventive antivirus control?

A. Scanning email attachments on the mail server
B. Restoring systems from clean copies
C. Disabling universal serial bus (USB) ports
D. An online antivirus scan with up-to-date virus definitions

ANSWERS TO SELF-ASSESSMENT QUESTIONS

5-1 **A. The most important aspect in a signature-based intrusion detection system (IDS) is its ability to protect against known (signature) intrusion patterns. Such signatures are provided by the vendor and are critical to protecting an enterprise from outside attacks.**
B. One of the key disadvantages of IDS is its inherent inability to scan for vulnerabilities at the application level.
C. An IDS cannot break encrypted data packets to identify the source of the incoming traffic.
D. A demilitarized zone (DMZ) is an internal network segment in which systems (e.g., a web server) accessible to the public are housed. In order to provide the greatest security and efficiency, an IDS should be placed behind the firewall so that it will detect only those attacks/intruders that enter the firewall.

5-2 A. Logging access to personal information is a good control in that it will allow access to be analyzed if there is concern of unauthorized access. However, it will not prevent access.
B. Restricting access to sensitive transactions will restrict access only to some of the data. It will not prevent access to other data.
C. The server and system security should be defined to allow only authorized staff members access to information about the staff whose records they handle on a day-to-day basis.
D. System access restricted to business hours only restricts when unauthorized access can occur and would not prevent such access at other times. It is important to consider that the data owner is responsible for determining who is allowed access via the written software access rules.

5-3 A. The security officer serving as the database administer, while a control weakness, does not carry the same disastrous impact as the absence of password controls.
B. The absence of password controls on the two database servers, where production data reside, is the most critical weakness.
C. Having no business continuity plan for the mainframe system's noncritical applications, while a control weakness, does not carry the same disastrous impact as the absence of password controls.
D. Most local area networks (LANs) not backing-up regularly, while a control weakness, does not carry the same disastrous impact as the absence of password controls.

5-4 **A. If a password is disclosed when single sign-on is enabled, there is a risk that unauthorized access to all systems will be possible.**
B. User access rights should remain unchanged by single sign-on, as additional security parameters are not implemented necessarily.
C. One of the intended benefits of single sign-on is the simplification of security administration.
D. One of the intended benefits of single sign-on is the unlikelihood of an increased workload.

5-5 A. The standard bandwidth of an integrated services digital network (ISDN) data link would not provide the quality of services required for corporate Voice-over Internet Protocol (VoIP) services.
B. To ensure that quality of service requirements are achieved, the VoIP service over the wide area network (WAN) should be protected from packet losses, latency or jitter. To reach this objective, the network performance can be managed to provide quality of service (QoS) and class of service (CoS) support using statistical techniques such as traffic engineering.
C. Wired equivalent privacy (WEP) is an encryption scheme related to wireless networking.
D. The VoIP phones are usually connected to a corporate local area network (LAN) and are not analog.

5-6 A. Benefits of cloud computing are redundancy and the ability to access systems and data in the event of a technical failure.
B. Considering that an insurance company must preserve the privacy/confidentiality of customer information, unauthorized access to information and data leakage are the major concerns.
C. The ability to investigate an incident is important, but most important is addressing the risk of an incident—the exposure of sensitive data.
D. If a cloud provider goes out of business, the data should still be available from backups.

5-7 A. A digital signature provides authentication and integrity.
B. Tunnel mode provides encryption and authentication of the complete IP package. To accomplish this, the authentication header (AH) and encapsulating security payload (ESP) services can be nested.
C. A digital certificate provides authentication and integrity.
D. The transport mode provides primary protection for the protocols' higher layers; that is, protection extends to the data field (payload) of an IP package.

5-8 A. Digital signatures will not identify, prevent or deter unauthorized reading.
B. Digital signatures will not identify, prevent or deter theft.
C. Digital signatures will not identify, prevent or deter unauthorized copying.
D. A digital signature includes an encrypted hash total of the size of the message as it was transmitted by its originator. This hash would no longer be accurate if the message was altered subsequently, indicating that the alteration had occurred.

5-9 **A. Choice A best describes a distribute denial-of-service (DDoS). Such attacks are centrally initiated and involve the use of multiple compromised computers. The attacks work by flooding the target site with spurious data, thereby overwhelming the network and other related resources. To achieve this objective the attacks need to be directed at a specific target and occur simultaneously.**
B. DDoS attacks are not locally initiated.
C. DDoS attacks are not initiated using a primary computer.
D. DDoS attacks are not staggered.

5-10 A. Scanning email attachments on the mail server is a preventive control. It will prevent infected email files from being opened by the recipients, which would cause their machines to become infected.
B. Restoring systems from clean copies is a preventive control. It will ensure that viruses are not introduced from infected copies or backups, which would reinfect machines.
C. Disabling universal serial bus (USB) ports is a preventive control. It prevents infected files from being copied from a USB drive onto a machine, which would cause the machine to become infected.

D. Antivirus software can be used to prevent virus attacks. By running regular scans, it can also be used to detect virus infections that have already occurred. Regular updates of the software are required to ensure it is able to update, detect and treat viruses as they emerge.

Section Two: Content

5.1 QUICK REFERENCE

Quick Reference Review

Chapter 5 addresses the need for the protection of information assets within an organization. Protection of information assets includes the key components that ensure confidentiality, integrity and availability (CIA) of information assets. The chapter evaluates design, implementation and monitoring of logical and physical access controls to ensure CIA. The chapter also evaluates network infrastructure security, environmental controls and processes and procedures used to store, retrieve, transport and dispose of confidential information assets. The chapter describes the various methods and procedures followed by organizations and focuses on the auditor's role in evaluating these procedures. Many of these topics may, on the surface, seem very familiar to candidates; however, it is important to note that the topics addressed in this chapter require a thorough knowledge of the technologies used and the potential control weaknesses that can be exploited by attackers. CISA candidates should be fully aware of and conversant with the components of network infrastructure security, logical access issues and the key elements of information security management.

CISA candidates should have a sound understanding of the following items, not only within the context of the present chapter, but also to correctly address questions in related subject areas. It is important to keep in mind that it is not enough to know these concepts from a definitional perspective. The CISA candidate must also be able to identify which elements may represent the greatest risk and which controls are most effective at mitigating this risk. Examples of key topics in this chapter are:

- Elements of information security management including senior management commitment and support, policies and procedures, organization, fraud risk factors, security control design, security awareness and education, monitoring and compliance, and incident handling and response
- General points of logical entry into a system including logical protection at the network, platform, database and application layers
- Identify how a failure at one layer could allow an unauthorized individual to bypass certain logical security mechanisms and gain access to confidential data
- Good practices for identification and authentication, including practices for handling default system accounts, normal user accounts and privileged user accounts, such as system administrators
- Various types of biometric technologies and the advantages and disadvantages of each
- Network infrastructure security including the various issues and risk associated with different technologies used in network infrastructures, and good practices for risk mitigation
  - Special attention should be focused on firewall implementation, the advantages and disadvantages of different types of intrusion detection/prevention systems, and encryption technologies.
- The importance of the proper maintenance of OS and other software, including using only known and acknowledged services and removing those that are not needed, patching the vulnerabilities and closing the ports that are not needed
- Environmental exposures and controls such as fire suppression systems, uninterruptible power supply (UPS), etc.
- Mobiles devices and the need for policies, procedures and encryption
- Social media and the risk in the enterprise
- The different models available with cloud computing including their risk and controls

5.2 INFORMATION SECURITY MANAGEMENT

Laying the foundation for effective information security management is the most critical factor in protecting information assets and privacy. Recent developments in the current environment—such as electronic trading through service providers and directly with customers, use of remote access facilities, and high-profile security exposures (e.g., viruses, denial-of-service [DoS] attacks, intrusions, identity theft, etc.)—have raised the profile of information and privacy risk and the need for effective information security management.

Security objectives to meet organization's business requirements include the following:

- Ensure the continued availability of their information systems and data.
- Ensure the integrity of the information stored on their computer systems and while in transit.
- Preserve the confidentiality of sensitive data while stored and in transit.
- Ensure conformity to applicable laws, regulations and standards.
- Ensure adherence to trust and obligation requirements in relation to any information relating to an identified or identifiable individual (i.e., data subject) in accordance with its privacy policy or applicable privacy laws and regulations.
- Ensure that sensitive data are adequately protected while stored and when in transit, based on organizational requirements.

COBIT 5 separates information goals into three subdimensions of quality:

- **Intrinsic quality**—The extent to which data values are in conformance with the actual or true values. It includes:
  - Accuracy—The extent to which information is correct and reliable
  - Objectivity—The extent to which information is unbiased, unprejudiced and impartial
  - Believability—The extent to which information is regarded as true and credible
  - Reputation—The extent to which information is highly regarded in terms of its source or content
- **Contextual and representational quality**—The extent to which information is applicable to the task of the information user and is presented in an intelligible and clear manner, recognizing that information quality depends on the context of use. It includes:
  - Relevancy—The extent to which information is applicable and helpful for the task at hand
  - Completeness—The extent to which information is not missing and is of sufficient depth and breadth for the task at hand
  - Currency—The extent to which information is sufficiently up to date for the task at hand
  - Appropriate amount of information—The extent to which the volume of information is appropriate for the task at hand
  - Concise representation—The extent to which information is compactly represented
  - Consistent representation—The extent to which information is presented in the same format
  - Interpretability—The extent to which information is in appropriate languages, symbols and units, with clear definitions
  - Understandability—The extent to which information is easily comprehended
  - Ease of manipulation—The extent to which information is easy to manipulate and apply to different tasks
- **Security/accessibility quality**—The extent to which information is available or obtainable. It includes:
  - Availability/timeliness—The extent to which information is available when required or is easily and quickly retrievable
  - Restricted access—The extent to which access to information is restricted appropriately to authorized parties

It is important to recognize that these objectives are necessary, but not sufficient, because patterns often come into play regarding the objective of retaining competitive advantage. However, this section will not deal with ways and approaches to maintain such advantage, but rather how to protect the information

systems from security pitfalls.

5.2.1 KEY ELEMENTS OF INFORMATION SECURITY MANAGEMENT

An IT system with state-of-the-art security features and devices will not be protected unless it is properly implemented and managed and carefully operated, monitored and reviewed. Security objectives cannot be met by only effecting technical and procedural protections. An educated security attitude and attention by all employees, management, and external service providers and external trusted IT users/partners are vital to the achievement of security objectives. Information security is more than just a mechanism. Information security also includes cultural aspects that must be embraced by all individuals within an organization for information security to be effective.

Information Security Management System

An information security management system (ISMS) is a framework of policies, procedures, guidelines and associated resources to establish, implement, operate, monitor, review, maintain and improve information security for all types of organizations. An ISMS is defined in the International Organization for Standardization (ISO)/International Electrotechnical Commission (IEC) 27000 series of standards and guidelines.

Introductory standard ISO/IEC 27000 defines the scope and vocabulary used throughout the ISMS standard and provides a directory of the publications that comprise the standard. This standard defines the requirements for an ISMS and establishes the basis for certification of an ISMS. ISO/IEC 27001 is the formal set of specifications against which organizations may seek independent certification of their information security management system. ISO/IEC 27002 contains a structured set of suggested controls that may be used by organizations as appropriate to address information security risk. Additional ISO/IEC 2700X publications offer guidance for managing information security in specific industries and situations.

The ISO/IEC 27000 series evolved from ISO/IEC 17799, which was based on the 1995 United Kingdom BSI standard BS7799 for the good practices of information security management. The ISO/IEC 27000 series may be purchased from ISO at www.iso.org or from the American National Standards Institute (ANSI) at *www.webstore.ansi.org*.

Note: For a detailed overview of Information Security Governance, please see chapter 2 Governance and Management of IT.

Figure 5.2 describes the related key elements of information security management.

Figure 5.2—Key Elements of Information Security Management	
Senior management leadership, commitment and support	Commitment and support from senior management are important for successful establishment and continuance of an information security management program. This is commonly known as the “tone at the top.”
Policies and procedures	The policy framework should be established with a concise top management declaration of direction, addressing the value of information assets, the need for security, and the importance of defining a hierarchy of classes of sensitive and critical assets. After approval by the governing body of the organization and by related roles and responsibilities, the information security program will be substantiated with the following: • Standards to develop minimum security baselines • Measurement criteria and methods • Specific guidelines, practices and procedures The policy should ensure resource conformity with laws and regulations. Security policies and procedures must be up to date and reflect business objectives, as well as generally accepted security standards and practices.
Organization	Responsibilities for the protection of individual assets should be clearly defined. The information security policy should provide general guidance on the allocation of security roles and responsibilities in the organization and, where necessary, detailed guidance for specific sites, assets, services and related security processes, such as IT recovery and business continuity planning.
Security awareness and education	All employees of an organization and, where relevant, third-party users should receive appropriate training and regular updates to foster security awareness and compliance with written security policies and procedures. For new employees, this training should occur before access to information or service is granted. A number of different mechanisms available for raising security awareness include: • Regular updates to written security policies and procedures • Formal information security training • Internal certification program for relevant personnel • Statements signed by employees and contractors agreeing to follow the written security policy and procedures, including nondisclosure obligations • Use of appropriate publication media for distribution of security-related material (e.g., company newsletter, web page, videos, etc.) • Visible enforcement of security rules and periodic audits • Security drills and simulated security incidents
Risk management	Processes should be in place to identify, assess, respond to and mitigate risk to information assets.
Monitoring and compliance	IS auditors are usually charged to assess, on a regular basis, the effectiveness of an organization’s security program(s). To fulfill this task, they must have an understanding of the protection schemes, the security framework and the related issues, including compliance with applicable laws and regulations. As an example, these issues may relate to organizational due diligence for security and privacy of sensitive information, particularly as it relates to specific industries (e.g., banking and financial institutions, health care).
Incident handling and response	A computer security incident is an event adversely affecting the processing of computer usage. This includes loss of confidentiality of information, compromise of integrity of information, denial of service, unauthorized access to systems, misuse of systems or information, theft and damage to systems. Other incidents include virus attacks and intrusion by humans within or outside the organization.

5.2.2 INFORMATION SECURITY MANAGEMENT ROLES AND RESPONSIBILITIES

All defined and documented responsibilities and accountabilities must be established and communicated to all relevant personnel and management. **Figure 5.3** presents roles and responsibilities of groups and individuals who may interact with information security management.

Figure 5.3—Roles and Responsibilities as Related to Information Security Management	
Information security steering committee	Security policies, guidelines and procedures affect the entire organization and, as such, should have the support and suggestions of end users, executive management, auditors, security administration, information systems personnel and legal counsel. Therefore, individuals representing

	various management levels should meet as a committee to discuss these issues and establish and approve security practices. The committee should be formally established with appropriate terms of reference. As an alternative, this role may be tasked to the IT strategy committee.
Executive management	Responsible for the overall protection of information assets, and for issuing and maintaining the policy framework.
Security advisory group	Responsible for defining the information security risk management process and acceptable level of risk and for reviewing the security plans of the organization. This group should include people involved in the business, provide comments on security issues to the chief security officer (CSO) and communicate to the business whether the security programs meet the business objectives.
Chief privacy officer (CPO)	A senior level corporate official responsible for articulating and enforcing the policies that companies use to protect their customers' and employees' privacy rights
Chief information security officer (CISO)	The person in charge of information security within the enterprise
Chief security officer (CSO)	The person usually responsible for all security matters both physical and digital in an enterprise
Process owners	Ensure appropriate security measures are consistent with organizational policy and are maintained
Information asset owners and data owners	Ownership entails responsibility for the owned asset. This includes conducting a risk assessment, selecting appropriate controls to mitigate the risk to an acceptable level and accepting the residual risk.
Users	Follow procedures set out in the organization's security policy and adhere to privacy and security regulations, which are often specific to sensitive application fields (e.g., health care, finance, legal, etc.)
External parties	Follow procedures set out in the organization's security policy, and adhere to privacy and security regulations, which are often specific to sensitive application fields (e.g., health care, finance, legal, etc.)
Information security administrator	Staff level position responsible for providing adequate physical and logical security for IS programs, data and equipment. Normally, the information security policies will provide the basic guidelines under which the security administrator will operate.
Security specialists/advisors	Assist with the design, implementation, management and review of the organization's security policy, standards and procedures
IT developers	Implement information security within their applications
IS auditors	Provide independent assurance to management on the appropriateness and effectiveness of information security objectives and the controls related to these objectives

5.2.3 CLASSIFICATION OF INFORMATION ASSETS

Effective control requires a detailed inventory of information assets. Creating this list is the first step in classifying assets and determining the level of protection needed for each asset.

Information assets have varying degrees of sensitivity and criticality in meeting business objectives. By assigning classes or levels of sensitivity and criticality to information resources and establishing specific security rules for each class, it is possible to define the level of access controls that should be applied to each information asset. Classification of information assets reduces the risk and cost of over- or under-protecting information resources in linking security to business objectives because it helps to build and maintain a consistent perspective of the security requirements for information assets throughout the organization.

The information owner is responsible for the information and should decide on the appropriate classification, based on the organization's data classification and handling policy. Classifications should be simple such as designations by differing degrees for sensitivity and criticality. End-user managers and security administrators can then use these classifications in their risk assessment process to assist with determining who should be able to access what, and the most appropriate level of such access. Most organizations use a classification scheme with three to five levels of sensitivity. The number of classification categories should take into consideration the size and nature of the organization and the fact that complex schemes may become too impractical to use.

Data classification is a major part of managing data as an asset. Data classification as a control measure should define:
- The importance of the information asset
- The information asset owner
- The process for granting access
- The person responsible for approving the access rights and access levels
- The extent and depth of security controls

Data classification must take into account legal, regulatory, contractual and internal requirements for maintaining privacy, confidentiality, integrity and availability of information. Data classification is also useful to identify who should have access to the production data used to run the business versus those who are permitted to access test data and programs under development. For example, application programmers or system development programmers should not have access to production data or programs.

Adopting a classification scheme and assigning the information to one sensitivity level enables uniform treatment of data, through applying level-specific policies and procedures rather than addressing each type of information. It is highly difficult to follow information security policies if documents and media are not assigned to a sensitivity level and users are not instructed how to deal with each piece of information. If documents or media are not labeled according to a classification scheme, this is an indicator of a potential misuse of information. Users might reveal confidential information because they did not know that the requirements prohibited disclosure. Social engineering capitalizes on this kind of misunderstanding at the end user level. An example of classification of information is shown in **figure 5.4**.

Figure 5.4—Classification of Information	
Public Information	Company brochures
Private Information	Internal policies, procedures, normal business email messages, information controlled by legislation, etc.
Sensitive Information	Unpublished financials, company secrets, etc.

5.2.4 FRAUD RISK FACTORS

Fraud is the crime of using dishonest methods to take something valuable from a person or organization. There can be many reasons why a person commits fraud, but one of the more accepted models is the fraud triangle, which was developed by criminologist Donald R. Cressey in the 1950s. Cressey believed that the three key elements in the fraud triangle are opportunity, motivation and rationalization.

Motivation refers to a perceived financial (or other) need. The fraudster may be in debt, hold a personal grudge, have a problem with drugs or gambling, or want to enjoy status symbols, such as a bigger house or car.

Rationalization refers to the way the fraudster justifies the crime to himself/herself. Rationalization may include thoughts such as "I deserved the money," "I was only borrowing the money," "my family needs the money," "my employer has loads of money anyway," or "my employer treats me unfairly."

Opportunity refers to the method by which the crime is to be committed. Opportunity is created by abuse of position and authority, poor internal controls, poor management oversight, etc. Failure to establish procedures to detect fraud increases the likelihood of fraud occurring. Opportunity is the element over which organizations—and, by extension, IS auditors—have the most control. When considering information assets, the opportunities to commit fraud can be limited by security controls. These controls typically include logical access (including those for third parties), segregation of duties (SoD), human resources security, etc.

5.2.5 INFORMATION SECURITY CONTROL DESIGN

Information security is maintained through the use of controls. Controls may be **proactive**, meaning that they attempt to prevent an incident, or controls may be **reactive**, meaning that they allow the detection, containment and recovery from an incident. Proactive controls are often called safeguards, and reactive controls are known as countermeasures. For example, a sign that warns a person about a dangerous condition is a safeguard, whereas a fire extinguisher or sprinkler system is a countermeasure.

Every organization has some controls in place, and a risk assessment should document these controls and their effectiveness in mitigating risk. In some cases, the controls may be sufficient, whereas in others, the controls may need adjustment or replacement. An effective control is one that prevents, detects and/or contains an incident and enables recovery from an event.

It is common for an organization to have some situations where the controls currently in place are not sufficient to adequately protect the organization. In most cases, this requires the adjustment of the current controls or the implementation of new controls. However, it may not be feasible to reduce the risk to an acceptable level by either adjusting or implementing controls due to reasons such as cost, job requirements or availability of controls. An example of this could be found in a small organization when an individual is given administrator rights on a system and there is not adequate SoD. In this case, it may not be feasible to implement a new or enhanced control; some personnel need administrator rights to perform their jobs, and the risk cannot justify the cost of hiring new staff to address SoD. In such instances, compensating controls may be considered to reduce the risk. Compensating controls address the weaknesses in the existing controls through concepts such as layered defense, increased supervision, procedural controls, or increased audits and logging of system activity. These measures will work to compensate for the risk that could not be addressed in other ways.

Managerial, Technical and Physical Controls

Controls are often divided into three groups, as shown in **figure 5.5**.

Figure 5.5—Control Methods

Category	Description
Managerial (administrative)	Controls related to the oversight, reporting, procedures and operations of a process. These include policy, procedures, balancing, employee development and compliance reporting.
Technical	Controls also known as logical controls and are provided through the use of technology, piece of equipment or device. Examples include firewalls, network or host-based intrusion detection systems (IDSs), passwords, and antivirus software. A technical control requires proper managerial (administrative) controls to operate correctly.
Physical	Controls that are locks, fences, closed-circuit TV (CCTV), and devices that are installed to physically restrict access to a facility or hardware. Physical controls require maintenance, monitoring and the ability to assess and react to an alert should a problem be indicated.

Further controls within these groups may be preventive, detective or corrective (see chapter 1 The Process of Auditing Information Systems, for more information). An example of a control matrix is shown in **figure 5.6**. Many controls may fit into more than one classification.

Figure 5.6—Control Matrix

	Managerial	Technical	Physical
Preventive	User registration process	Login screen	Fence
Detective	Audit	Intrusion detection system (IDS)	Motion sensor
Corrective	Remove access	Network isolation	Close fire doors

Control Standards and Frameworks

The selection of controls requires the evaluation and implementation of the right control in the right way. Based on data collected through an analysis method (e.g., cost-benefit, return on investment [ROI], etc.), management will decide on the best available control, or group of controls, to mitigate a specific risk. However, a poorly implemented control may pose a significant risk to the organization by creating a false sense of security or leading to a denial of service if the control does not function correctly. The implementation of a technical control requires that the control is surrounded by proper procedures, the personnel that operate it are adequately trained, a person is assigned ownership of the control (often the person who owns the risk), and the control is monitored and tested to ensure its correct operation and effectiveness.

Many industries have standards that may be used as a benchmark for security across the industry sector. One example is the Payment Card Industry Data Security Standard (PCI DSS), which is used as a standard for all organizations that process payment cards (e.g., debit cards, credit cards, etc.). This is an

example of an industry standard, but compliance is not required by law. Such standards, and the frameworks that implement those standards, are found in the health care, accounting, audit and telecommunications industries. In some regulated industries, regulations require compliance with a standard, such as the electrical power industry. To meet the requirements of the standard, a framework is often used to describe how an organization can achieve compliance.

A control framework is defined as a set of fundamental controls that facilitates the discharge of business process owner responsibilities to prevent financial or information loss in an enterprise. Therefore, it can be seen as the implementation of controls intended to support and protect business operations and preserve asset value.

Control Monitoring and Effectiveness
To support the ability to monitor and report on risk, the IS auditor should validate that processes, logs and audit hooks have been placed into the control framework. This allows for the monitoring and evaluation of controls. As controls are designed, implemented and operated, the IS auditor should ensure that logs are enabled, controls are able to be tested and regular reporting procedures are developed.

The IS auditor should also ensure that the capability to monitor a control and to support monitoring systems is addressed in control design. If the organization is using a managed security service provider (MSSP) or a security information and event management (SIEM) system, the ability to capture data, and the notification to the operations staff on the deployment of the system, are necessary.

5.2.6 SYSTEM ACCESS PERMISSION

System access permission is the prerogative to act on a computer resource. This usually refers to a technical privilege, such as the ability to read, create, modify or delete a file or data; execute a program; or open or use an external connection.

System access to computerized information resources is established, managed and controlled at the physical and/or logical level. Physical access controls restrict the entry and exit of personnel to an area such as an office building, suite, data center or room containing information processing equipment such as a local area network (LAN) server. There are many types of physical access controls including badges, memory cards, guard keys, true floor-to-ceiling wall construction fences, locks and biometrics. Logical system access controls restrict the logical resources of the system (transactions, data, programs, applications) and are applied when the subject resource is needed. On the basis of identification and authentication of the user that requires a given resource and by analyzing the security profiles of the user and the resource, it is possible to determine if the requested access is to be allowed (i.e., what information users can utilize, the programs or transactions they can run, and the modifications they can make). Such controls may be built into the operating system (OS), invoked through separate access control software and incorporated into application programs, database systems, network control devices and utilities (e.g., real-time performance monitors).

Physical or logical system access to any computerized information should be on a documented need-to-know basis (often referred to as “role-based”) where there is a legitimate business requirement based on least privilege. Other considerations for granting access are accountability (e.g., unique user ID) and traceability (e.g., logs). These principles should be used by IS auditors when they evaluate the appropriateness of criteria for defining permissions and granting security privileges. Organizations should establish such basic criteria for assigning technical access to specific data, programs, devices and resources, including who will have access and what level of access they will be allowed. For instance, it may be desirable for everyone in the organization to have access to specific information on the system such as the data displayed on an organization’s daily calendar of meetings. The program that formats and displays the calendar might be modifiable by only a few system administrators, while the OS controlling that program might be directly accessible by still fewer.

The IT assets under logical security can be grouped in four layers—networks, platforms (OSs), databases and applications. This concept of layered security for system access provides greater scope and granularity of control to information resources. For example, network and platform layers provide pervasive general systems control over users authenticating into systems, system software and application configurations, data sets, load libraries, and any production data set libraries. Database and application controls generally provide a greater degree of control over user activity within a particular business process by controlling access to records, specific data fields and transactions.

The information owner or manager who is responsible for the accurate use and reporting of information should provide written authorization for users or defined roles to gain access to information resources under their control. The manager should hand over this documentation directly to the security administrator to ensure that mishandling or alteration of the authorization does not occur.

Logical access capabilities are implemented by security administration in a set of access rules that stipulate which users (or groups of users) are authorized to access a resource at a particular level (e.g., read-, update- or execute-only) and under which conditions (e.g., time of the day or a subset of computer terminals). The security administrator invokes the appropriate system access control mechanism upon receipt of a proper authorization request from the information owner or manager to grant a specified user the rights for access to, or use of, a protected resource. The IS auditor should be aware that access is granted to the organization’s information systems utilizing the principles of need-to-know, least privilege and SoD.

Reviews of access authorization should be evaluated regularly to ensure that they are still valid. Personnel and departmental changes, malicious efforts, and just plain carelessness result in authorization creep and can impact the effectiveness of access controls. Many times, access is not removed when personnel leave an organization, thus increasing the risk of unauthorized access. For this reason, the information asset owner should review access controls periodically with a predetermined authorization matrix that defines the least-privileged access level and authority for an individual/role with reference to his/her job roles and responsibilities. Any access exceeding the access philosophy in authorized matrix or in actual access levels granted on a system should be updated and changed accordingly. One of the good practices is to integrate the review of access rights with human resource processes. When an employee transfers to a different function (i.e., promotions, lateral transfers or demotions), access rights are adjusted at the same time. Development of a security-conscious culture increases the effectiveness of access controls.

Nonemployees with access to corporate IS resources should also be held responsible for security compliance and be accountable for security breaches. Nonemployees include contract employees, vendor programmers/analysts, maintenance personnel, clients, auditors, visitors and consultants. It should be understood that nonemployees are also accountable to the organization’s security requirements.

5.2.7 MANDATORY AND DISCRETIONARY ACCESS CONTROLS

Mandatory access controls (MACs) are logical access control filters used to validate access credentials that cannot be controlled or modified by normal users or data owners; they act by default. Controls that may be configured or modified by the users or data owners are called discretionary access controls

(DACs).

MACs are a good choice to enforce a ground level of critical security without possible exception, if this is required by corporate security policies or other security rules. A MAC could be carried out by comparing the sensitivity of the information resources, such as files, data or storage devices, kept on a user-unmodifiable tag attached to the security object with the security clearance of the accessing entity such as a user or an application. With MACs, only administrators may make decisions that are derived from policy. Only an administrator may change the category of a resource, and no one may grant a right of access that is explicitly forbidden in the access control policy. MACs are prohibitive; anything that is not expressly permitted is forbidden.

DACs are a protection that may be activated or modified at the discretion of the data owner. This would be the case of data owner-defined sharing of information resources, where the data owner may select who will be enabled to access his/her resource and the security level of this access. DACs cannot override MACs; DACs act as an additional filter, prohibiting still more access with the same exclusionary principle.

When information systems enforce MAC policies, the systems must distinguish between MAC and the discretionary policies that offer more flexibility. This distinction must be ensured during object creation, classification downgrading and labeling.

5.2.8 PRIVACY PRINCIPLES AND THE ROLE OF IS AUDITORS

Privacy means freedom from unauthorized intrusion or disclosure of information about an individual (data subject). It is an organizationwide matter that, by its nature, requires a consistent approach throughout the organization. Good practice to ensure this includes the following:
- Privacy should be considered from the outset and be built in by design. It should be systematically built into policies, standards and procedures from the beginning.
- Private data should be collected fairly in an open, transparent manner. Only the data required for the purpose should be collected in the first instance.
- Private data should be kept securely throughout their life cycle.
- Private data should only be used and/or disclosed for the purpose for which they were collected.
- Private data should be accurate, complete and up to date.
- Private data should be deleted when they are no longer required.

To best meet these challenges, management should perform a privacy impact analysis. IS auditors may be asked to support or perform this review. Such assessments should:
- Pinpoint the nature of personally identifiable information associated with business processes.
- Document the collection, use, disclosure and destruction of personally identifiable information.
- Ensure that accountability for privacy issues exists.
- Identify legislative, regulatory and contractual requirements for privacy.
- Be the foundation for informed policy, operations and system design decisions based on an understanding of privacy risk and the options available for mitigating that risk.

Based on the results, it should be possible to create a consistent format and structured process for analyzing technical and legal compliance with relevant regulations and internal policies. This structured process would provide a framework to ensure that privacy is considered in all IT projects, from the conceptual and requirements analysis stage to the final design approval, funding, implementation and communication stage, so that privacy compliance is built into projects rather than retrofitted.

The focus and extent of privacy impact analysis or assessment may vary depending on changes in technology, processes or people as shown in **figure 5.7**.

Figure 5.7—Changes That Impact Privacy

Technology	Processes	People
• New programs • Changes in existing programs • Additional system linkages • Data warehouse • New products	• Change management • Business process reengineering • Enhanced accessibility rules • New systems • New operations • Vendors	• Business partners • Service providers

The IS auditor may also be called on to give assurance on compliance with privacy policy, laws and other regulations. To fulfill this role, the IS auditor should:
- Identify and understand legal requirements regarding privacy from laws, regulations and contract agreements. Examples include the Organisation for Economic Co-operation and Development (OECD) Guidelines on the Protection of Privacy and Transborder Flows of Personal Data, European Union Data Protection Directives and the US-EU Safe Harbor Framework. Depending on the assignment, IS auditors may need to seek legal or expert opinion on these.
- Review management's privacy policy to ascertain whether it takes into consideration the requirement of these privacy laws and regulations.
- Check whether personal sensitive data are correctly managed in respect to these requirements.
- Verify that the correct security measures are adopted.

As laws and regulations vary from country to country, there may be a question as to how to approach privacy-related compliance requirements. *ISO/IEC 29100:2011: Information technology—Security techniques—Privacy framework* contains a description of the basic elements of a privacy framework and which privacy principles should be used. Furthermore, ISO/IEC 27018:2014 establishes commonly accepted control objectives, controls and guidelines for implementing measures to protect personally identifiable information (PII) in accordance with the privacy principles in ISO/IEC 29100 for the public cloud computing environment.

Note: The CISA exam does not test on specific privacy laws and standards because they vary by country.

5.2.9 CRITICAL SUCCESS FACTORS TO INFORMATION SECURITY MANAGEMENT

Managers and employees within an organization often tend to consider information security as a secondary priority if compared with their own efficiency or effectiveness matters because these have a direct and material impact on the outcome of their work.

For this reason, strong leadership, direction and commitment by senior management on security training is needed. This commitment should be supported with a comprehensive program of formal security awareness training.

Security Awareness, Training and Education
Risk that is inherent in using computing systems cannot be addressed through technical security mechanisms. An active security awareness program can greatly reduce risk by addressing the behavioral element of security through education and consistent application of awareness techniques. Security awareness programs should focus on common user security concerns—such as password selection, appropriate use of computing resources, email and web browsing safety, and social engineering—and the programs should be tailored to specific groups. In addition, users are the front line for the detection of threats that may not be detectable by automated means (e.g., fraudulent activity and social engineering). Employees should be educated on recognizing and escalating such events to enhance loss prevention.

An important aspect of ensuring compliance with the information security program is the education and awareness of the organization regarding the importance of the program. In addition to the need for information security, all personnel must be trained in their specific responsibilities related to information security. Particular attention must be paid to those job functions that require virtually unlimited data access. People whose job is to transfer data may have access to data in most systems, and those doing performance tuning can change most OS configurations. People whose job is to schedule batch jobs have the authority to run most system jobs applications. Programmers have access to change application code. These functions are not typically managed by information security. Although it is possible to set up elaborate monitoring controls, it is not technically feasible or financially prudent for information security to provide oversight adequate to ensure that all data transfer jobs that transmit reports send them only to appropriately authorized recipients. Although information security can ensure that there is clear policy, develop applicable standards and assist in process coordination, management in all areas must assist in providing oversight.

Employee awareness should start from the point of joining the organization (e.g., through induction training) and continue regularly. Techniques for delivery need to vary to prevent them from becoming stale or boring and may also need to be incorporated into other organizational training programs.

Security awareness programs should consist of the following:
- Training (often administered online)
- Quizzes to gauge retention of training concepts
- Security awareness reminders such as posters, newsletters or screensavers
- A regular schedule of refresher training

In larger organizations, there may be a large enough population of middle and senior management to warrant special management-level training on information security awareness and operations issues.

All employees of an organization and, where relevant, third-party users must receive appropriate training and regular updates on the importance of security policies, standards and procedures in the organization. This includes security requirements, legal responsibilities and business controls, as well as training in the correct use of information processing facilities (e.g., login procedures, use of software packages). For new employees, this should occur before access to information or services is granted and be a part of new employee orientation.

A methodical approach should be taken to developing and implementing the education and awareness program with the following aspects being considered:
- Who is the intended audience (senior management, business managers, IT staff, end users)?
- What is the intended message (policies, procedures, recent events)?
- What is the intended result (improved policy compliance, behavioral change, better practices)?
- What communication method will be used (computer-based training [CBT], all-hands meeting, intranet, newsletters, etc.)?
- What is the organizational structure and culture?

A number of different mechanisms available for raising information security awareness include:
- Computer-based security awareness and training programs
- Email reminders and security tips
- Written security policies and procedures (and updates)
- Nondisclosure statements signed by the employee
- Use of different media in promulgating security (e.g., company newsletter, web page, videos, posters, login reminders)
- Visible enforcement of security rules
- Simulated security incidents for improving security
- Rewarding employees who report suspicious events
- Periodic reviews
- Job descriptions
- Performance reviews

A second critical success factor to information security management is that a professional risk-based approach must be used systematically to identify sensitive and critical information resources and to ensure that there is a clear understanding of threats and risk. Thereafter, appropriate risk assessment activities should be undertaken to mitigate unacceptable risk and ensure that residual risk is at an acceptable level. For more information, see sections 2.8 Risk Management, 4.3 IT Asset Management, and 5.2.3 Classification of Information Assets.

5.2.10 INFORMATION SECURITY AND EXTERNAL PARTIES

The security of the organization’s information and information processing facilities that are accessed, processed, communicated to or managed by external parties should be maintained and should not be reduced by the introduction of external party products or services. Any access to the organization’s information processing facilities and processing and communication of information by external parties should be controlled. Controls should be agreed to and defined in an agreement with the external party. Organizations shall gain the right to audit the implementation and operation of the resulting security controls.

These external party arrangements can include:
- Service providers such as Internet service providers (ISPs), network providers, telephone services, maintenance and support services
- Managed security services
- Customers
- Suppliers
- Outsourcing facilities and/or operations (e.g., IT systems, data collection services, call center operations)
- Management and business consultants and auditors
- Developers and suppliers (e.g., of software products and IT systems)
- Cleaning, catering and other outsourced support services
- Temporary personnel, student placement and other casual short-term appointments

Such agreements can help to reduce the risk associated with external parties.

Identification of Risk Related to External Parties
The risk to the organization's information and information processing facilities from business processes involving external parties should be identified and appropriate controls implemented before granting access. Where there is a need to allow an external party access to the information processing facilities or information of an organization, a risk assessment should be carried out to identify any requirements for specific controls. The identification of risk related to external party access should take into account the issues depicted in **figure 5.8**.

Figure 5.8—Risk Related to External Party Access

- The information processing facilities an external party is required to access
- The type of access the external party will have to the information and information processing facilities:
  - Physical access (e.g., to offices, computer rooms and filing cabinets)
  - Logical access (e.g., to an organization's databases and information systems)
  - Network connectivity between the organization's and the external party's network(s) (e.g., permanent connection and remote access)
  - Whether the access is taking place onsite or offsite
- The value and sensitivity of the information involved and its criticality for business operations
- The controls necessary to protect information that is not intended to be accessible by external parties
- The external party personnel involved in handling the organization's information
- How the organization or personnel authorized to have access can be identified, the authorization verified and how often this needs to be reconfirmed
- The different means and controls employed by the external party when storing, processing, communicating, sharing, exchanging and destroying information
- The impact of access not being available to the external party when required and the external party entering or receiving inaccurate or misleading information
- Practices and procedures to deal with information security incidents and potential damages and the terms and conditions for the continuation of external party access in the case of an information security incident
- Legal and regulatory requirements and other contractual obligations relevant to the external party that should be taken into account
- How the interests of any other stakeholders may be affected by the arrangements

Access by external parties to the organization's information should not be provided until the appropriate controls have been implemented and, where feasible, a contract has been signed defining the terms and conditions for the connection or access and the working arrangement. Generally, all security requirements resulting from work with external parties or internal controls should be reflected by the agreement with the external party. It should be ensured that the external party is aware of its obligations and accepts the responsibilities and liabilities involved in accessing, processing, communicating or managing the organization's information and information processing facilities.

External parties might put information at risk if their security management is inadequate. Controls should be identified and applied to administer external party access to information processing facilities. For example, if there is a special need for confidentiality of the information, nondisclosure agreements might be used. Organizations may face risk associated with interorganizational processes, management and communication, if a high degree of outsourcing is applied or where there are several external parties involved.

Addressing Security When Dealing With Customers
All identified security requirements should be addressed before giving customers access to the organization's information or assets.

The items presented in **figure 5.9** should be considered to address security prior to giving customers access to any of the organization's assets (depending on the type and extent of access given, not all of them may apply).

Figure 5.9—Customer Access Security Considerations

- Asset protection, including:
  - Procedures to protect the organization's assets, including information and software, and management of known vulnerabilities
  - Procedures to determine whether any compromise of the assets (e.g., loss or modification of data, has occurred)
  - Integrity
  - Restrictions on copying and disclosing information
- Description of the product or service to be provided
- The different reasons, requirements and benefits for customer access
- Access control policy, covering:
  - Permitted access methods and the control and use of unique identifiers such as user IDs and passwords
  - An authorization process for user access and privileges
  - A statement that all access that is not explicitly authorized is forbidden
  - A process for revoking access rights or interrupting the connection between systems
- Arrangements for reporting, notification and investigation of information inaccuracies (e.g., of personal details), information security incidents and security breaches
- The target level of service and unacceptable levels of service
- The right to monitor and revoke any activity related to the organization's assets
- The respective liabilities of the organization and the customer
- Responsibilities with respect to legal matters and ensuring that the legal requirements are met (e.g., data protection legislation), taking into account different national legal systems if the agreement involves cooperation with customers in other countries
- Intellectual property rights (IPRs), copyright assignment and protection of any collaborative work

The security requirements related to customers accessing organizational assets can vary considerably depending on the information processing facilities and information being accessed. These security requirements can be addressed using customer agreements that contain all identified risk and security requirements.

Agreements with external parties may also involve other parties. Agreements granting an external party access should include an allowance for designation of other eligible parties and conditions for their access and involvement.

Addressing Security in Third-party Agreements

Third-party agreements involving accessing, processing, communicating or managing the organization's information or information processing facilities or adding products or services to information processing facilities should cover all relevant security requirements. The agreement should ensure that there is no misunderstanding between the organization and the third party. The organization should ensure that the agreement includes adequate indemnification provisions to protect against potential losses caused by the actions of the third party.

The contract terms listed in **figure 5.10** should be considered for inclusion in the agreement to satisfy the identified security requirements.

Figure 5.10—Recommended Contract Terms for Third-party Agreements

- Compliance with the organization's information security policy by the third party
- Controls to ensure asset protection, including:
  - Procedures to protect organizational assets, including information, software and hardware
  - Any required physical protection controls and mechanisms
  - Controls to ensure protection against malicious software
  - Procedures to determine whether any compromise of the assets (e.g., loss or modification of information, software and hardware) has occurred
  - Controls to ensure the return or destruction of information and assets at the end of or at an agreed point in time during the agreement
  - Confidentiality, integrity, availability and any other relevant property of the assets
  - Restrictions on copying and disclosing information, and using confidentiality agreements
- User and administrator training in methods, procedures and security
- A means to ensure user awareness of information security responsibilities and issues
- Provision for the transfer of personnel, where appropriate
- Responsibilities regarding hardware and software installation and maintenance
- A clear reporting structure and agreed reporting formats
- A clear and specified process for change management
- Access control policy, covering:
  - The different reasons, requirements and benefits that make the access by the third party necessary
  - Permitted access methods and the control and use of unique identifiers such as user IDs and passwords
  - An authorization process for user access and privileges
  - A requirement to maintain a list of individuals authorized to use the services being made available and what their rights and privileges are with respect to such use
  - A statement that all access that is not explicitly authorized is forbidden
  - A process for revoking access rights or interrupting the connection between systems
- Arrangements for reporting, notification and investigation of information security incidents and security breaches as well as violations of the requirements stated in the agreement
- A description of the product or service to be provided and a description of the information to be made available along with its security classification
- The target level of service and unacceptable levels of service
- The definition of verifiable performance criteria, their monitoring and reporting
- The right to monitor and revoke any activity related to the organization's assets
- The right to audit responsibilities defined in the agreement, to have those audits carried out by a third party and to enumerate the statutory rights of auditors (and, where appropriate, the provision of a service auditor's report)
- The establishment of an escalation process for problem resolution
- Service continuity requirements, including measures for availability and reliability, in accordance with an organization's business priorities
- The respective liabilities of the parties to the agreement
- Responsibilities with respect to legal matters and ensuring that the legal requirements are met (e.g., data protection legislation), taking into account different national legal systems if the agreement involves cooperation with organizations in other countries
- IPRs and copyright assignment and protection of any collaborative work
- Involvement of the third party with subcontractors, and the security controls these subcontractors need to implement
- Conditions for renegotiation/termination of agreements such as:
  - A contingency plan in case either party wishes to terminate the relationship before the end of the agreements
  - A provision for renegotiation of agreements if the security requirements of the organization change
- Current documentation of asset lists, licenses, agreements or rights relating to them
- Non-assignability of the contract

In general, it is very difficult to ensure the return or destruction of confidential information disclosed to a third party at the end of the agreement. To prevent unauthorized copies or use, printed documents should be consulted on site. Using technical controls, such as digital rights management (DRM) where access control technologies are used by publishers, copyright holders and individuals to impose limitations on the usage of digital content and devices, should be considered to set up the desired constraints such as the printing of the document, copying, authorized readers or using it after a certain date.

The agreements can vary considerably for different organizations and among the different types of third parties. Therefore, care should be taken to include all identified risk and security requirements in the agreements. Where necessary, the required controls and procedures can be expanded in a security management plan.

If information security management is outsourced, the agreements should address how the third party will guarantee that adequate security, as defined by the risk assessment, will be maintained and how security will be adapted to identify and deal with changes to risk. Some of the differences between outsourcing and the other forms of third-party service provision include the question of liability, planning the transition period and potential disruption of operations during this period, contingency planning arrangements and due diligence reviews, and collection and management of information on security incidents. Therefore, it is important that the organization plans and manages the transition to an outsourced arrangement and has suitable processes in place to manage changes and the renegotiation/termination of agreements.

The procedures for continuing processing in the event that the third party becomes unable to supply its services need to be considered in the agreement to avoid any delay in arranging replacement services. Agreements with third parties may also involve other parties. Agreements granting third-party access should include allowance for designation of other eligible parties and conditions for their access and involvement.

A requirement for the third party to have certified compliance with recognized security standards (e.g., ISO 27001) may need to be considered.

Generally, agreements are primarily developed by the organization. There may be occasions in some circumstances where an agreement may be developed and imposed upon an organization by a third party. The organization needs to ensure that its own security is not unnecessarily impacted by third-party requirements stipulated in imposed agreements.

5.2.11 HUMAN RESOURCES SECURITY AND THIRD PARTIES

Proper information security practices should be in place to ensure that employees, contractors and third-party users understand their responsibilities and are suitable for their assigned roles. These practices can reduce the risk of theft, fraud or misuse of facilities. Specific security practices include:

- Security responsibilities should be addressed prior to employment in adequate job descriptions, and in terms and conditions of employment.
- All candidates for employment, contractors and third-party users should be adequately screened, especially for sensitive jobs.
- Employees, contractors and third-party users of information processing facilities should sign an agreement on their security roles and responsibilities, including the need to maintain confidentiality.

Security roles and responsibilities of employees, contractors and third-party users should be defined and documented in accordance with the organization's information security policy.

Screening

All candidates for employment, contractors or third-party users should be subject to background verification checks. These should be carried out and documented in accordance with relevant laws, regulations and ethics, and proportional to the business requirements, the classification of the information to be accessed and the perceived risk. When using an agency to provide contractors, the contract with the agency should clearly specify the agency's responsibilities for screening and the notification procedures they need to follow if screening has not been completed or if the results give cause for doubt or concern. In the same way, the agreement with the third party should clearly specify all responsibilities and notification procedures for screening.

Terms and Conditions of Employment

As part of their contractual obligation, employees, contractors and third-party users should agree and sign the terms and conditions of their employment, which should state their and the organization's responsibilities for information security. The terms and conditions of employment should reflect the organization's security policy in addition to clarifying and stating:

- That all employees, contractors and third-party users who are given access to sensitive information should sign a confidentiality or nondisclosure agreement prior to being given access to information processing facilities
- The employee, contractor and any other user's legal responsibilities and rights (e.g., regarding copyright laws or data protection legislation)
- Responsibilities for the classification of information and management of organizational assets associated with information systems and services handled by the employee, contractor or third-party user
- Responsibilities of the employee, contractor or third-party user for the handling of information received from other companies or external parties
- Responsibilities of the organization for the handling of personal information, including personal information created as a result of, or in the course of, employment with the organization
- Responsibilities that are extended outside the organization's premises and outside normal working hours (e.g., in the case of working at home)
- Actions to be taken if the employee, contractor or third-party user disregards the organization's security requirements

The organization should ensure that employees, contractors and third-party users agree to terms and conditions concerning information security appropriate to the nature and extent of access they will have to the organization's assets associated with information systems and services. Where appropriate, responsibilities contained within the terms and conditions of employment should continue for a defined period after the end of the employment.

During Employment

Management should require employees, contractors and third-party users to apply security in accordance with the established policies and procedures of the organization. Specific responsibilities should be documented in approved job descriptions. This will help ensure that employees, contractors and third-party users are aware of information security threats and concerns, their responsibilities and liabilities, and are equipped to support organizational security policy in the course of their normal work and to reduce the risk of human error. Management responsibilities should be defined to ensure that security is applied throughout an individual's employment within the organization. An adequate level of awareness, education and training in security procedures and the correct use of information processing facilities should be provided to all employees, contractors and third-party users to minimize possible security risk. A formal disciplinary process for handling security breaches should be established.

Termination or Change of Employment

When an employee, contractor or third-party user exits the organization, responsibilities should be in place to manage this process, including the return of all equipment and removal of all access rights. Communication of termination responsibilities should include ongoing security requirements and legal responsibilities. Where appropriate, responsibilities contained within any confidentiality agreement and the terms and conditions of employment continuing for a defined period after the end of the employee, contractor or third-party user's employment should also be communicated. Responsibilities and duties still valid after termination of employment should be contained in the employee, contractor or third-party user's contracts.

Removal of Access Rights

The access rights of all employees, contractors and third-party users to information and information processing facilities should be removed upon termination of their employment, contract or agreement, or adjusted upon change. The access rights that should be removed or adapted include physical and logical access, keys, identification cards, information processing facilities, subscriptions, and removal from any documentation that identifies them as a current member of the organization. This should include notifying partners and relevant third parties—if a departing employee has access to the third party premises. If a departing employee, contractor or third-party user has known passwords for accounts remaining active, these should be changed upon termination or change of employment, contract or agreement. Access rights for information assets and information processing facilities should be reduced or removed before the employment terminates or changes, depending on the evaluation of risk factors such as:

- Whether the termination or change is initiated by the employee, contractor or third-party user, or by management and the reason of termination
- The current responsibilities of the employee, contractor or any other user
- The value of the assets currently accessible

Procedures should be in place to ensure that information security management is promptly informed of all employee movements, including employees

leaving the organization.

5.2.12 COMPUTER CRIME ISSUES AND EXPOSURES

Computer systems can be used to fraudulently obtain money, goods, software or corporate information. Crimes can also be committed when the computer application process or data are manipulated to accept false or unauthorized transactions. There is also the simple, nontechnical method of computer crime: stealing computer equipment.

Computer crime can be performed without anything physically being taken or stolen, and it can be done remotely. Simply viewing computerized data can provide an offender with enough intelligence to steal ideas or confidential information (intellectual property). In case of the systems connected to wide area networks (WANs) or the Internet, the crime scene could be anywhere in the world, making the investigation very difficult. Cyber-criminals take advantage of existing gaps in the legislation of different countries when planning cyberattacks in order to avoid prosecution.

Committing crimes that exploit the computer and the information it contains can be damaging to the reputation, morale and the continued existence of an organization. Loss of customers or market share, embarrassment to management and legal actions against the organization can result. Threats to business include the following:

- **Financial loss**—These losses can be direct, through loss of electronic funds, or indirect, through the costs of correcting the exposure.
- **Legal repercussions**—There are numerous privacy and human rights laws an organization should consider when developing security policies and procedures. These laws can protect the organization but also can protect the perpetrator from prosecution. In addition, not having proper security measures could expose the organization to lawsuits from investors and insurers if a significant loss occurs from a security violation. Most companies must also comply with industry-specific regulatory agencies' requirements. The IS auditor should obtain legal assistance when reviewing the legal issues associated with computer security.
- **Loss of credibility or competitive edge**—Many organizations, especially service firms such as banks, savings and loans and investment firms, need credibility and public trust to maintain a competitive edge. A security violation can damage this credibility severely, resulting in loss of business and prestige.
- **Blackmail/industrial espionage/organized crime**—By gaining access to confidential information or the means to adversely impact computer operations, a perpetrator can extort payments or services from an organization by threatening to exploit the security breach or publicly disclose the confidential information of the organization. Also, by gaining access, the perpetrator could obtain proprietary information and sell it to a competitor.
- **Disclosure of confidential, sensitive or embarrassing information**—As noted previously, such events can damage an organization's credibility and its means of conducting business. Legal or regulatory actions against the company may also be the result of disclosure.
- **Sabotage**—Some perpetrators are not looking for financial gain. They merely want to cause damage due to a dislike of the organization or for self-gratification. "Hacktivism" occurs when perpetrators make nonviolent use of illegal or legally ambiguous digital tools in pursuit of political ends.

It is important that the IS auditor knows and understands the differences between computer crime and computer abuse to support risk analysis methodologies and related control practices. What constitutes a crime depends on the jurisdiction and the court sentence. Certain breaches of security may be civil or criminal offenses. This brings into play requirements for what the organization needs to do should a crime be suspected (i.e., protection of evidence, reporting of a crime, etc.).

Perpetrators in computer crimes are often the same people who exploit physical exposures, although the skills needed to exploit logical exposures are more technical and complex. Possible perpetrators include:

- **Hackers (also referred to as crackers)**—Persons with the ability to explore the details of programmable systems and the knowledge to stretch or exploit their capabilities, whether ethical or not. Hackers are typically attempting to test the limits of access restrictions to prove their ability to overcome the obstacles. Some often do not access a computer with the intent of destruction, although this is often the result. Types of hackers include hacktivists and criminal hackers. Some hackers seek to commit a crime through their actions for some level of personal gain or satisfaction. The terms hack and crack are often used interchangeably.
- **Script kiddies**—Script kiddies refer to individuals who use scripts and programs written by others to perform their intrusions and are often incapable of writing similar scripts on their own.
- **Employees (authorized or unauthorized)**—Affiliated with the organization and given system access based on job responsibilities, these individuals can cause significant harm to an organization. Therefore, screening prospective employees through appropriate background checks is an important means of preventing computer crimes within the organization.
- **IT personnel**—These individuals have the easiest access to computerized information, as they are the custodians of this information. In addition to logical access controls, good SoD and supervision help in reducing logical access violations by these individuals.
- **End users**—Personnel who often have broad knowledge of the information within the organization and have easy access to internal resources
- **Former employees**—Former employees who have left on unfavorable terms may have access if it was not immediately removed at the time of the employee's termination or if the system has "back doors."
- **Nations**—As more critical infrastructure is controlled from the Internet (e.g., supervisory control and data acquisition [SCADA] systems) and more nation's key organizations and businesses rely on the Internet, it is not uncommon for nations to attack each other.
- **Interested or educated outsiders**—These may include:
  - Competitors
  - Terrorists
  - Organized criminals
  - Hackers looking for a challenge
  - Script kiddies for the purpose of curiosity, joyriding and testing their newly acquired tools/scripts and exploits
  - Crackers
  - Phreakers
- **Part-time and temporary personnel**—Remember that facility contractors such as office cleaners often have a great deal of physical access and could perpetrate a computer crime.
- **Third parties**—Vendors, visitors, consultants or other third parties who, through projects, gain access to the organization's resources and could perpetrate a crime
- **Opportunists**—Where information is inadvertently left unattended or left for destruction, a passerby can access same
- **Accidental unaware**—Someone who unknowingly perpetrates a violation

Other examples of criminals include small-time crooks, organized crime and state-sponsored criminal activities.

Although collaboration has been improved in solving cybercrimes committed from one country to another, political issues existing between some countries might hinder an investigation. Therefore, additional preventive measures should be taken to protect information systems vulnerable to international attacks.

Figures 5.11 and **5.12** describe common attack methods and techniques for computer crimes. Perpetrators may use one or more methods in tandem to commit a crime.

Figure 5.11—Computer Crimes

Source of the Attack	Target of the Attack	Examples
Computer is the target of the crime. Perpetrator uses another computer to launch an attack.	Specific identified computer	• Denial of service (DoS) • Hacking
Computer is the subject of the crime. Perpetrator uses computer to commit crime and the target is another computer.	Target may or may not be defined. Perpetrator launches the attack with no specific target in mind.	• Distributed DoS • Malware
Computer is the tool of the crime. Perpetrator uses computer to commit crime but the target is not the computer.	Target is data or information stored on the computer.	• Fraud • Unauthorized access • Phishing • Installing key loggers
Computer symbolizes the crime. Perpetrator lures the user of computers to get confidential information.	Target is user of the computers.	• Social engineering methods: – Phishing – Fake web sites – Scam mail – Spam mail – Fake resumes for employment

Figure 5.12—Common Attack Methods and Techniques

Alteration Attack	Occurs when unauthorized modifications affect the integrity of the data or code Examples: Unauthorized alteration of binary code during the software development life cycle (SDLC) or addition of unauthorized libraries during recompilation of existing programs Cryptographic hash is a primary defense against alteration attacks.
Botnets	Comprise a collection of compromised computers (called zombie computers) running software, usually installed via worms, Trojan horses or back doors Examples: Denial-of-service (DoS) attacks, adware, spyware and spam
Brute Force Attack	Attack launched by an intruder, using many of the password-cracking tools available at little or no cost, on encrypted passwords and attempts to gain unauthorized access to an organization's network or host-based systems
Denial-of-service (DoS) Attack	Examples: ICMP flood attack: • Smurf attack—Occurs when misconfigured network devices allow packets to be sent to all hosts on a particular network via the broadcast address of the network • Ping flood—Occurs when the target system is overwhelmed with ping packets • SYN flood—Sends a flood of TCP/SYN packets with forged sender address, causing half-open connections and saturates available connection capacity of the target machine Teardrop attack—Involves sending mangled IP fragments with overlapping, oversized payloads to the target machine Peer-to-peer attack—Causes clients of large peer-to-peer file sharing hubs to disconnect from their peer-to-peer network and to connect to the victim's web site instead. As a result, several thousand computers may aggressively try to connect to a target web site, causing performance degradation.
Denial-of-service (DoS) Attack *(cont.)*	Permanent denial-of-service (PDoS) attack (also known as phlashing)—Damages a system hardware to the extent of replacement Application-level flood attack: • Buffer overflow consumes available memory or CPU time. • Brute force attack—Floods the target with an overwhelming flux of packets, oversaturating its connection bandwidth or depleting the target's system resources • Bandwidth-saturating flood attack—Relies on the attacker having higher bandwidth available than the victim • Banana attack—Redirects outgoing messages from the client back onto the client, preventing outside access, as well as flooding the client with the sent packets • Pulsing zombie—A DoS attack in which a network is subjected to hostile pinging by different attacker computers over an extended time period. This results in a degraded quality of service and increased workload for the network's resources. Nuke—A DoS attack against computer networks in which fragmented or invalid ICMP packets are sent to the target. Modified ping utility is used to repeatedly send corrupt data, thus slowing down the affected computer to a complete stop. Distributed denial-of-service attack (DDoS)—Occurs when multiple compromised systems flood the bandwidth or resources of the targeted system Reflected attack—Involves sending forged requests to a large number of computers that will reply to the requests. The source IP address is spoofed to that of the targeted victim, causing the replies to flood. Unintentional attack—Web site ends up denied, not due to a deliberate attack by a single individual or group of individuals, but simply due to a sudden enormous spike in popularity
Dial-in Penetration Attack/War	An intruder determines the dial-in phone number ranges from external sources, such as the Internet. The intruder may also employ social

Dialing	engineering tactics to get information from a company receptionist or a knowledgeable employee inside the company
Eavesdropping	An intruder gathers the information flowing through the network with the intent of acquiring and releasing the message contents for either personal analysis or for third parties who might have commissioned such eavesdropping. This is significant when considering that sensitive information, traversing a network, can be seen in real time by all other machines, including email, passwords and, in some cases, keystrokes. These activities can enable the intruder to gain unauthorized access, to fraudulently use information such as credit card accounts and to compromise the confidentiality of sensitive information that could jeopardize or harm an individual's or an organization's reputation.
Email Attacks and Techniques	Email Bombing—Characterized by abusers repeatedly sending an identical email message to a particular address Email spamming (also known as unsolicited commercial email (UCE) or junk email)—a variant of bombing and refers to sending email to hundreds or thousands of users (or to lists that expand to that many users). It may also occur innocently as a result of sending a message to mailing lists and not realizing that the list explodes to thousands of users or as a result of using a responder message, such as a vacation alert, that is not set up correctly. • Spam causes inconvenience and has severe impacts on productivity and thus is considered a business risk. • When spam is responded to, the email address of the recipient is validated and gives away information. • Spam may be combined with email spoofing (see below), making it more difficult to determine from whom the email is coming. • Spam is managed using the Sender Permitted Form (SPF) protocol and with the help of tools such as Bayesian filtering and greylisting. Email Spoofing—May occur in different forms, but all have a similar result: a user receives an email message that appears to have originated from one source but actually was sent from another source. Email spoofing is often an attempt to trick the user into making a damaging statement or releasing sensitive information such as passwords or account information. Examples of spoofed email that could affect the security of a site include: • Email claiming to be from a system administrator and requesting users to change their passwords to a specified string and threatening to suspend their account if they do not make the change • Email claiming to be from a person in authority and requesting users to send a copy of a password file or other sensitive information Phishing—The criminally fraudulent process of attempting to acquire sensitive information, such as usernames, passwords and credit card details, by masquerading as a trustworthy entity in an electronic communication. Phishing techniques include social engineering, link manipulation and web site forgery. Spear phishing—A pinpoint attack against a subset of people (users of a web site or product, employees of a company, members of an organization) to undermine that company or organization
Flooding	A DoS attack that brings down a network or service by flooding it with large amounts of traffic. The host's memory buffer is filled by flooding it with connections that cannot be completed.
Interrupt Attack	Occurs when a malicious action is performed by invoking the OS to execute a particular system call Example: A boot sector virus typically issues an interrupt to execute a write to the boot sector.
Malicious Codes	Trojan horses (often called Trojans)—Programs that are disguised as useful programs such as OS patches, software packages or games. Once executed, however, Trojans perform actions that the user did not intend, such as opening certain ports for subsequent access by the intruder. Logic bomb—A program or a section of a program that is triggered when a certain condition, time or event occurs. Logic bombs typically result in sabotage of computer systems and are commonly deployed by disgruntled insiders who have access to programs. For example, when terminated from an organization, a disgruntled software programmer could devise a logical bomb to delete critical files or databases. Logic bombs can also be used against attackers. Administrators sometimes intentionally install pseudo flaws, also called honey tokens, that look vulnerable to attack but really act as alarms or triggers of automatic actions when the intruder attempts to exploit the flaw. Trap doors—Commonly called back doors. Bits of code embedded in programs by programmers to quickly gain access during the testing or debugging phase. If an unscrupulous programmer purposely leaves in this code (or simply forgets to remove it), a potential security hole is introduced. Hackers often plant a back door on previously compromised systems to gain subsequent access. Threat vector analysis (a type of defense-in-depth architecture), SoD and code audits help to defend against logic bombs and trap/back doors.
Man-in-the-middle Attack	The following scenarios are possible: • The attacker actively establishes a connection to two devices. The attacker connects to both devices and pretends to each of them to be the other device. Should the attacker's device be required to authenticate itself to one of the devices, it passes the authentication request to the other device and then sends the response back to the first device. Having authenticated himself/herself in this way, the attacker can then interact with the device as he/she wishes. To successfully execute this attack, both devices have to be connectable. • The attacker interferes while the devices are establishing a connection. During this process, the devices have to synchronize the hop sequence that is to be used. The aggressor can prevent this synchronization so that both devices use the same sequence but a different offset within the sequence.
Masquerading	An active attack in which the intruder presents an identity other than the original identity. The purpose is to gain access to sensitive data or computing/network resources to which access is not allowed under the original identity. Masquerading also attacks the authentication attribute by letting a genuine session authentication take place and subsequently enters the information flow, masquerading as one of the authenticated users of the session. Impersonation both by people and machines falls under this category. Masquerading by machines (also known as IP spoofing)—A forged IP address is presented. This form of attack is often used as a means of breaking a firewall.
Message Modification	Involves the capturing of a message and making unauthorized changes or deletions (of full streams or parts of the message), changing the sequence or delaying transmission of captured messages. This attack can have disastrous effects if, for example, the message is an instruction to a bank to make a payment.
Network Analysis	An intruder applies a systematic and methodical approach known as footprinting to create a complete profile of an organization's network security infrastructure. During this initial reconnaissance phase, the intruder uses a combination of tools and techniques to build a repository of information about a particular company's internal network. This probably would include information about system aliases, functions, internal addresses, and potential gateways and firewalls. Next, the intruder focuses on systems within the targeted address space that responded to these network queries. Once a system has been targeted, the intruder scans the system's ports to determine what services and OS are running on the targeted system, possibly revealing vulnerable services that could be exploited.
Packet Replay	A combination of passive and active modes of attacks. The intruder passively captures a stream of data packets as the stream moves along an unprotected or vulnerable network. These packets are then actively inserted into the network as if the stream were another genuine message stream. This form of attack is effective particularly where the receiving end of the communication channel is automated and will act on receipt and interpretation of information packets without human intervention.
Pharming	An attack that aims to redirect the traffic of a web site to a bogus web site. Pharming can be conducted either by changing the host's file on a victim's computer or by exploiting a vulnerability in DNS server software. DNS servers are computers responsible for resolving Internet names into their real addresses—they are the "signposts" of the Internet. Compromised DNS servers are sometimes referred to as "poisoned." In recent

	years, both pharming and phishing have been used to steal identity information. Pharming has become a major concern to businesses hosting e-commerce and to online banking web sites. Sophisticated measures known as antipharming are required to protect against this serious threat. Antivirus software and spyware removal software cannot protect against pharming.
Piggybacking	The act of following an authorized person through a secured door or electronically attaching to an authorized telecommunications link to intercept and possibly alter transmissions. Piggybacking is considered a physical access exposure.
Race Conditions (also known as Time of Check [TOC]/Time of Use [TOU] attacks)	Exploit a small window of time between the time that the security control is applied and the time that the service is used. The exposure to a race condition increases in proportion to the time difference between TOC and TOU. Interference occurs when a device or system attempts to perform two or more operations at the same time, but the nature of the device or system requires the operations to happen in proper sequence. Race conditions occur due to interferences caused by the following conditions: • Sequence or nonatomic—These conditions are caused by untrusted processes, such as those invoked by an attacker, that may get in between the steps of the secure program. • Deadlock, livelock or locking failure—These conditions are caused by trusted processes running the same program. Since these different processes may have the same privileges, they may interfere with each other, if not properly controlled. Careful programming and good administration practices help to reduce race conditions.
Remote Maintenance Tools	If not securely configured and controlled, can be used as an attack method by malicious hackers to remotely gain elevated access and cause damage to the target system
Resource Enumeration and Browsing	When the attacker lists the various resources (names, directories, privileges, shares, policies) on targeted hosts and networks Browsing attack—A form of a resource enumeration attack and is performed by a manual search, frequently aided with commands and tools available in software, OSs or add-on utilities
Salami	Involves slicing small amounts of money from a computerized transaction or account. Similar to the rounding down technique. The difference between the rounding down technique and the salami technique is that, in rounding down, the program rounds off by the smallest money fraction. For example, in the rounding down technique, a US $1,235,954.39 transaction may be rounded to US $1,235,954.35. On the other hand, the salami technique truncates the last few digits from the transaction amount, so US $1,235,954.39 becomes US $1,235,954.30 or $1,235,954.00, depending on the algorithm/formula built into the program. In fact, other variations of the same technique are applied to rates and percentages.
Social Engineering	The human side of breaking into a computer system. Organizations with strong technical security countermeasures (such as authentication processes, firewalls and encryption) may still fail to protect their information systems. This situation may happen if an employee unknowingly gives away confidential information (e.g., passwords and IP addresses) by answering questions over the phone with someone they do not know or replying to an email message from an unknown person. Some examples of social engineering include impersonation through a telephone call, dumpster diving and shoulder surfing. The best means of defense for social engineering is an ongoing security awareness program, wherein all employees and third parties (who have access to the organization's facilities) are educated about the risk involved in falling prey to social engineering attacks.
Traffic Analysis	An inference attack technique that studies the communication patterns between entities in a system and deduces information. This typically is used when messages are encrypted and eavesdropping would not yield meaningful results. Traffic analysis can be performed in the context of military intelligence or counter-intelligence and is a concern in computer security.
Unauthorized Access Through the Internet or World Wide Web	Unauthorized access through the Internet or web-based services. Many Internet software packages contain vulnerabilities that render systems subject to attack. Additionally, many of these systems are large and difficult to configure, resulting in a large percentage of unauthorized access incidents. Examples include: • Email forgery (simple mail transfer protocol) • Telnet passwords transmitted in the clear (via path between client and server) • Altering the binding between IP addresses and domain names to impersonate any type of server. As long as the DNS is vulnerable and used to map universal resource locators (URLs) to sites, there can be no integrity on the Web. • Releasing common gateway interface (CGI) scripts as shareware. CGI scripts often run with privileges that give them complete control of a server. • Client-side execution of scripts (via Java™ in Java applets), which presents the danger of running code from an arbitrary location on a client machine
Viruses, Worms and Spyware/Malware	Viruses—Involve the insertion of malicious program code into other executable code that can self-replicate and spread from computer to computer, via sharing of removable computer media, USB removable devices, transfer of logic over telecommunication lines or direct link with an infected machine/code. A virus can harmlessly display cute messages on computer terminals, dangerously erase or alter computer files, or simply fill computer memory with junk to a point where the computer can no longer function. An added danger is that a virus may lie dormant for some time until triggered by a certain event or occurrence, such as a date or being copied a prespecified number of times, during which time the virus has silently been spreading. Worms—Destructive programs that may destroy data or use up tremendous computer and communication resources, but worms do not replicate like viruses. Such programs do not change other programs but can run independently and travel from machine to machine across network connections by exploiting vulnerability and application/system weaknesses. Worms also may have portions of themselves running on many different machines. Spyware/Malware—Similar to viruses. Examples are keystroke loggers and system analyzers that collect potentially sensitive information, such as credit card numbers, bank details, etc., from the host and then transmit the information to the originator when an online connection is detected.
War Chalking	The practice of marking a series of symbols (outward-facing crescents) on sidewalks and walls to indicate nearby wireless access points. These markings are used to identify hotspots, where other computer users can connect to the Internet wirelessly and at no cost. War chalking was inspired by the practice of unemployed migrant workers, during the Great Depression in the US, using chalk marks to indicate which homes were friendly.
War Driving	The practice of driving around businesses or residential neighborhoods while scanning with a laptop computer, hacking tool software and sometimes with a global positioning system (GPS) to search for wireless network names. While driving around the vicinity of a wireless network, an attacker might be able to see the wireless network name, but the use of wireless security will determine whether the attacker can do anything beyond viewing the wireless network name. With wireless security enabled and properly configured, war drivers cannot see the network name and are unable to send data, interpret data sent on the wireless network, access the shared resources of the wireless or wired network (shared files, private web sites), or use the Internet connection. Without wireless security enabled and properly configured, war drivers can send data, interpret data sent on the wireless network, access the shared resources of the wireless or wired network (shared files, private web sites), install viruses, modify or destroy confidential data, and use

	the Internet connection without the knowledge or consent of the owner. For example, a malicious user might use the Internet connection to send thousands of spam email messages or launch attacks against other computers. The malicious traffic could be traced back to the owner's home.
War Walking	Similar to war driving, but a vehicle is not used. The potential hacker walks around the vicinity with a handheld device. Currently, there are several free hacking tools that fit in these mini-devices.

5.2.13 SECURITY INCIDENT HANDLING AND RESPONSE

To minimize damage from security incidents and to recover and to learn from such incidents, a formal incident response capability should be established. Incident response should include the following phases:
- Planning and preparation
- Detection
- Initiation
- Recording
- Evaluation
- Containment
- Eradication
- Escalation
- Response
- Recovery
- Closure
- Reporting
- Postincident review
- Lessons learned

The organization and management of an incident response capability should be coordinated or centralized with the establishment of key roles and responsibilities. This should include:
- A coordinator who acts as the liaison to business process owners
- A director who oversees the incident response capability
- Managers who manage individual incidents
- Security specialists who detect, investigate, contain and recover from incidents
- Nonsecurity technical specialists who provide assistance based on subject matter expertise
- Business unit leader liaisons (legal, human resources, public relations, etc.)

In establishing this process, employees and contractors are made aware of procedures for reporting the different types of incidents (e.g., security breach, threat, weakness or malfunction) that might have an impact on the security of organizational assets. They should be required to report any observed or suspected incidents as quickly as possible to the designated point of contact. The organization should establish a formal disciplinary process for dealing with those who commit security breaches such as employees, third parties, etc. To address incidents properly, it is necessary to collect evidence as soon as possible after the occurrence. Legal advice may be needed in the process of evidence collection and protection.

Incidents occur because vulnerabilities are not addressed properly. Incident management processes should include vulnerabilities management practices. A postincident review phase should determine which vulnerabilities were not addressed and why, and input provided for improvement to the policies and procedures implemented to address vulnerabilities. Also, analyzing the cause of incidents may reveal errors in the risk analysis, indicating that the residual risk is higher than the calculated values and inappropriate countermeasures have been taken to reduce inherent risk.

Ideally, an organizational computer security incident response team (CSIRT) or computer emergency response team (CERT) should be formed with clear lines of reporting, and responsibilities for standby support should be established. Organizational CSIRT will act as an efficient detective and corrective control. Additionally, with its members' participation and involvement in security awareness programs, exercises and workshops, it can demonstrate a preventive control.

Organizational CSIRT should also disseminate security alerts such as recent threats, security guidelines and security updates to the users and assist them in understanding the security risk of errors and omissions. Organizational CSIRT should act as single point of contact for all incidents and issues related to information security, should also respond to abuse reports pertaining to the network of its constituency.

An IS auditor should ensure that the CSIRT is actively involved with users to assist them in the mitigation of risk arising from security failures and also to prevent security incidents. Auditors should also ensure that there is a formal, documented plan and that it contains vulnerabilities identification, reporting and incident response procedures to common, security-related threats/issues, such as:
- Virus outbreak
- Web defacement
- Abuse notification
- Unauthorized access alert from audit trails
- Security attack alerts from intrusion detection systems (IDSs)
- Hardware/software theft
- System root compromises
- Physical security breach
- Spyware/malware/Trojans detected on personal computers (PCs)
- Fake defamatory information in media, including on web sites
- Forensic investigations

Additionally, automated IDSs should be in place to notify administrators in a real-time manner of a potential incident and define a process for determining the severity of the incidents and the steps to take in high-risk situations. Please refer to section 2.12.5 Business Continuity Planning Incident Management, for more information.

5.3 LOGICAL ACCESS

Logical access controls are the primary means used to manage and protect information assets. They enact and substantiate management-designed policies and procedures intended to protect these assets and the controls are designed to reduce risk to a level acceptable to an organization. IS auditors need to understand this relationship. In doing so, IS auditors should be able to analyze and evaluate the effectiveness of a logical access control in accomplishing information security objectives and avoiding losses resulting from exposures. These exposures can result in minor inconveniences to a total shutdown of computer functions.

5.3.1 LOGICAL ACCESS EXPOSURES

Technical exposures are one type of exposure that exists due to accidental or intentional exploitation of logical access control weaknesses. Intentional exploitation of technical exposures might lead to computer crime. However, not all computer crimes exploit technical exposures.

Technical exposures are the unauthorized activities interfering with normal processing, such as implementation or modification of data and software, locking or misusing user services, destroying data, compromising system usability, distracting processing resources, or spying data flow or users activities at either the network, platform (OS), database or application level. Technical exposures include:

- **Data leakage**—Involves siphoning or leaking information out of the computer. This can involve dumping files to paper, or can be as simple as stealing computer reports and tapes. Unlike product leakage, data leakage leaves the original copy, so it may go undetected.
- **Wiretapping**—Involves eavesdropping on information being transmitted over telecommunications lines
- **Computer shutdown**—Initiated through terminals or personal computers connected directly (online) or remotely (via the Internet) to the computer. Only individuals who know a high-level logon ID usually can initiate the shutdown process, but this security measure is effective only if proper security access controls are in place for the high-level logon ID and the telecommunications connections into the computer. Some systems have proven to be vulnerable to shutting themselves down under certain conditions of overload.

Figure 5.12 presents common attack methods and techniques.

5.3.2 FAMILIARIZATION WITH THE ENTERPRISE'S IT ENVIRONMENT

For IS auditors to effectively assess logical access controls within their organization, they first need to gain a technical and organizational understanding of the organization's IT environment. The purpose of this is to determine which areas from a risk standpoint warrant IS auditing attention in planning current and future work. This includes reviewing the network, OS platform, database and application security layers associated with the organization's IT information systems architecture.

5.3.3 PATHS OF LOGICAL ACCESS

Access or points of entry to an organization's IS infrastructure can be gained through several avenues. Each avenue is subject to appropriate levels of access security.

These paths can be direct, as is the case for a PC terminal user tying directly into a mainframe. This happens when the IS environment is under direct control of the main system and when the users are locally known individuals, with well-defined access profiles. More complex is the case of a LAN, where many specific IS resources are tied to a common linking structure. The LAN resources may have different access paths/levels, normally mediated through LAN connectivity, and the network itself is considered an important IS resource at a higher access level. A combination of direct, local network and remote access paths is the most common configuration. Complexity is increased by a number of intermediate devices that act as "security doors" among the various environments. The need of crossing low-security or totally open IT spaces, such as the Internet, also necessitates increased complexity. An example of an access path through common nodes is a back-end or front-end interconnected network of systems for internally or externally based users. Front-end systems are network-based systems connecting an organization to outside, untrusted networks, such as corporate web sites, where a customer can access the web site externally to initiate transactions that connect to a proxy server application which in turn connects to a back-end database system to update a customer database. Front-end systems can also be internally based to automate business, paperless processes that tie into back-end systems in a similar manner.

General Points of Entry

General points of entry to either front-end or back-end systems control the accesses from an organization's networking or telecommunications infrastructure into their information resources (e.g., applications, databases, facilities, networks). The approach followed is based on a client-server model. A large organization can have thousands of interconnected network servers. Connectivity in this environment needs to be controlled through a smaller set of primary domain controllers (servers), which enable a user to obtain access to specific secondary points of entry (e.g., application servers, databases, etc.).

General modes of access into this infrastructure occur through the following:

- **Network connectivity**—Access is gained by linking a PC to a segment of an organizations' network infrastructure, either through a physical or a wireless connection. At a minimum, such access requires user identification and authentication to a domain-controlling server. More specific access to a particular application or database may also require the users to identify and authenticate themselves to that particular server (secondary point of entry). Other modes of access into the infrastructure can also occur through network management devices, such as routers and firewalls, which should be strictly controlled.
- **Remote access**—A user connects remotely to an organization's server, which generally requires the user to identify and authenticate him/herself to the server for access to specific functions that can be performed remotely (e.g., email, File Transfer Protocol [FTP] or some application-specific function). Complete access to view all network resources usually requires a virtual private network (VPN), which allows a secure authentication and connection into those resources where privileges have been granted. Remote access points of entry can be extensive and should be centrally controlled where possible.

From a security standpoint, it is incumbent upon the organization to know all of the points of entry into its information resource infrastructure which, in many organizations, will not be a trivial task (e.g., thousands of remote access users). This is significant because any point of entry not appropriately controlled can potentially compromise the security of an organization's sensitive and critical information resources. When performing detailed network assessments and access control reviews, IS auditors should determine whether all points of entry are known and should support management's effort in obtaining the resources to identify and manage all access paths.

5.3.4 LOGICAL ACCESS CONTROL SOFTWARE

Information technology has made it possible for computer systems to store and contain large quantities of sensitive data, increase the capability of sharing resources from one system to another and permit many users to access the system through Internet/intranet technologies. All of these factors have made organizations' IS resources more widely and promptly accessible and available.

To protect an organization's information resources, access control software has become even more critical in assuring the confidentiality, integrity and availability of information resources. The purpose of access control software is to prevent the unauthorized access and modification to an organization's sensitive data and the use of system critical functions.

To achieve this kind of control, it is necessary to apply access controls across all layers of an organization's IS architecture, including networks, platforms or OSs, databases, and application systems. Each of them usually features some form of identification and authentication, access authorization, checking of specific information resources, and logging and reporting of user activities.

The greatest degree of protection in applying access control software against internal and external users' unauthorized access is at the network and platform/OS levels. These systems are also referred to as general support systems, and they make up the primary infrastructure on which applications and database systems will reside.

OS access control software interfaces with network access control software and resides on network layer devices (e.g., routers, firewalls) that manage and control external access to organizations' networks. Additionally, OS access control software interfaces with database and/or application systems access controls to protect system libraries and user data sets.

General operating and/or application systems access control functions include the following:
- Create or change user profiles
- Assign user identification and authentication
- Apply user logon limitation rules
- Notification concerning proper use and access prior to initial login
- Create individual accountability and auditability by logging user activities
- Establish rules for access to specific information resources (e.g., system-level application resources and data)
- Log events
- Report capabilities

Database and/or application-level access control functions include the following:
- Create or change data files and database profiles
- Verify user authorization at the application and transaction level
- Verify user authorization within the application
- Verify user authorization at the field level for changes within a database
- Verify subsystem authorization for the user at the file level
- Log database/data communications access activities for monitoring access violations

In summary, access control software is provided at different levels within an IS architecture, where each level provides a certain degree of security. Properties of such relationships are that upper layers (applications, databases) are dependent on lower, infrastructure-type layers to protect general system resources. Upper layers provide the granularity needed at the application level in segregating duties by function.

5.3.5 IDENTIFICATION AND AUTHENTICATION

Identification and authentication (I&A) in logical access control software is the process of establishing and proving one's identity. It is the process by which the system obtains from a user his/her claimed identity and the credentials needed to authenticate this identity, and validates both pieces of information.

I&A is a critical building block of computer security because it is needed for most types of access control and is necessary for establishing user accountability. User accountability requires the linking of activities on a computer system to specific individuals and, therefore, requires the system to identify users. For most systems, I&A is the first line of defense because it prevents unauthorized people (or unauthorized processes) from entering a computer system or accessing an information asset. If users are not properly identified and authenticated, particularly in today's open-system–networked environments, organizations have a higher exposure to risk of unauthorized access.

Some of I&A's more common vulnerabilities that may be exploited to gain unauthorized system access include:
- Weak authentication methods (e.g., no enforcement of password minimum length, complexity and change frequency)
- Use of simple or easily guessed passwords
- The potential for users to bypass the authentication mechanism
- The lack of confidentiality and integrity for the stored authentication information
- The lack of encryption for authentication and protection of information transmitted over a network
- The user's lack of knowledge on the risk associated with sharing authentication elements (e.g., passwords, security tokens)

Authentication is typically categorized as "something you know" (e.g., password), "something you have" (e.g., token card) and "something you are (or do)" (a biometric feature). These techniques can be used independently or in combination to authenticate and identify a user. For example, a single-factor technique (something you know) involves the use of the traditional logon ID and password. Something you know, such as a personal identification number (PIN), combined and associated with something you have, such as a token card, is known as a two-factor authentication technique. Something you are is a biometric authentication technique, such as a palm or iris biometric scan. Each of these techniques is described in detail in the following sections.

A combination of more than one method, such as token and password (or PIN or token and biometric device), is referred to as "multifactor" authentication.

Identification and authentication are separate systems. They differ in respect to:
- Meaning

- Methods, peripherals and techniques supporting them
- Requirements in terms of secrecy and management
- Attributes—authentication does not have attributes in itself, while an identity may have a defined validity in time and other information attached to it.
- The fact that identity does not normally change, while authentication tokens bound to secrecy must be regularly replaced to preserve their reliability

Logon IDs and Passwords

Logon IDs and passwords are the components of a user identification and authentication process, where the authentication is based on something you know. The computer can maintain an internal list of valid logon IDs and a corresponding set of access rules for each logon ID. These access rules are related to the computer resources. As a minimum requirement, access rules are usually specified at the OS level (controlling access to files) or within individual application systems (controlling access to menu functions and types of data or transactions).

The logon ID should be restricted to provide individual, but not group identification. If a group of users is to be formed for interchangeability, the system usually offers the ability to attach a logon ID to a named group, with common rights. Each user gets a unique logon ID that can be identified by the system. The format of logon IDs is typically standardized.

FEATURES OF PASSWORDS

A password provides individual authentication. It should be easy for the user to remember, but difficult for an intruder to determine.

Initial passwords may be allocated by the security administrator or generated by the system itself. When the user logs on for the first time, the system should force a password change to improve confidentiality. Initial password assignments should be randomly generated. The ID and password should be communicated in a controlled manner to ensure that only the appropriate user receives this information. New accounts without an initial password assignment should be suspended.

If the wrong password is entered a predefined number of times, the logon ID should be automatically locked out. Locking-out may be made permanent (only the administrator may unlock the ID) or temporary (the system automatically unlocks the ID after a system-specified time period).

Users that have forgotten their password must notify a security administrator. This is the only person with sufficient privileges to reset the password and, in case this is necessary, to unlock the logon ID. The security administrator should reactivate the logon ID only after verifying the user's identification (challenge/response system), much like a bank verifies an account holder's ID before giving information over the phone (such as mother's maiden name). To verify, the security administrator should return the user's call after verifying his/her extension or calling his/her supervisor for verification.

Passwords should be hashed (a type of one-way encryption) and stored using a sufficiently strong algorithm. This allows checking passwords without the need of recording them explicitly. To reduce the risk of an intruder gaining access to other users' logon IDs, passwords should not be displayed in any form. Passwords are normally masked on a computer screen, and they are not shown on computer reports. Passwords should not be kept on index or card files or written on pieces of paper taped somewhere near the computer or inside a person's desk.

Passwords should be changed on a regular basis (e.g., every 30 days). The frequency should depend upon the criticality of the information access level, the nature of the organization, the IS architecture and technologies used, etc. Passwords should be changed by the user at his/her computer, rather than by the administrator or in any location where their new password might be observed. The best method is to force the change by notifying the user prior to the password expiration date. The risk of allowing voluntary password changes is that users will not change their passwords unless forced to do so. Password management is stronger if a history of previously used passwords is maintained by the system and their re-use prohibited for a period, such as no re-use of the last 12 passwords.

A password for a logon ID should only be known by the individual user; if a password is known to more than one person, the accountability of the user for all activity within the account cannot be enforced.

Special treatment should be applied to supervisor or administrator accounts. These accounts frequently allow full access to the system. Normally there are a limited number of such accounts per system/authentication level. For accountability, the administrator password should be known only by one individual. On the other hand, the organization should be able to access the system in an emergency situation when the administrator is not available. To enable this, practices such as keeping the administrator password in a sealed envelope, kept in a locked cabinet and available only to top managers should be implemented. This is sometimes referred to as a "firecall" ID.

All of the guidelines above should be formalized in a password policy and made as a mandatory requirement. An acceptable use policy should also include the requirement to follow the policy.

IDENTIFICATION AND AUTHENTICATION GOOD PRACTICES

Logon ID requirements include the following:

- Logon ID syntax should follow an internal naming rule, however this rule should be kept as confidential as the IDs themselves.
- Default system accounts—such as Guest, Administrator and Admin—should be renamed or disabled whenever technically possible.
- Logon IDs not used after a predetermined period of time should be deactivated to prevent possible misuse. This can be done automatically by the system or manually by the security administrator.
- The system should automatically disconnect or lock a logon session if no activity has occurred for a period of time. This reduces the risk of misuse of an active logon session left unattended, because the user went to lunch, left for home, went to a meeting or otherwise forgot to log off. This is often referred to as a session time out. Regaining access should require the reentry of the authentication method, password, token, etc.

Password syntax rules include:

- Ideally, passwords should be a minimum of eight characters in length. The length of the password will, at times, depend on the sensitivity of the systems and data to be protected and the capability of the system being used. A passphrase is generally accepted as a more secure password.
- Passwords should require a combination of at least three of the following characteristics: alphanumeric, upper and lower case letters and special characters.
- Passwords should not be particularly identifiable with the user (such as first name, last name, spouse name, pet's name, etc.). Some organizations prohibit the use of vowels, making word association/guessing of passwords more difficult.
- The system should enforce regular password changes every 30 days and not permit previous password(s) to be used for at least a year after being changed.

At a minimum, the above rules should be applied to individuals with privileged system account authority (system administrators, security administrators, etc.) versus general users. Users with privileged authority need such access in establishing and managing appropriate system configurations. However, such privileges enable the user to bypass any access control software restrictions that may exist on the system. The general rule to apply is that, the greater the degree of sensitivity of the access rights, the stricter the access controls should be.

Token Devices, One-time Passwords
In a common two-factor authentication technique, the user is assigned a microprocessor-controlled smart card, USB key or mobile device application synchronized with a specific authentication device on the system. This smart card/key/app is set to generate unique, time-dependent, pseudo-random strings that are called "session passwords" and are recognized by the authenticating device and program. They attest that the user is currently in possession of his/her own smart device. Each string is valid for only one logon session. Users must either physically read out and retype the string, or insert the smart card/USB key in a reader/USB slot along with typing in their own memorized password to gain access to the system. This technique involves something you have (a device subject to theft) and something you know (a personal identification number).

Biometrics
Biometric access controls are the best means of authenticating a user's identity based on a unique, measurable attribute or trait for verifying the identity of a human being. This control restricts computer access based on a physical (something you are) or behavioral (something you do) characteristic of the user. Due to advances in hardware efficiencies and storage, biometric systems are becoming a more viable option as an access control mechanism.

Using a biometric generally involves use of a reader device that interprets the individual's biometric features before permitting authorized access. However, this is not a flawless process because certain biometric features can change (e.g., scarred fingerprints, signature irregularities and change in voice). For this reason, biometric access control systems are not all equally effective and easy to use.

Entering a user's biometric into a system occurs through an enrollment process by storing a user's particular biometric feature. This occurs through an iterative averaging process of acquiring a physical or behavioral sample, extracting unique data from the sample (converted into a mathematical code), creating an initial template, comparing new sample(s) with what has been stored and developing a final template that can be used to authenticate the user. Subsequent samples will be used in determining whether a match or non-match condition exists for granting access.

Three percentage-based quantitative measures are used to determine the performance of biometric control devices. One measure, the false-rejection rate (FRR), or type-I error rate, is the number of times an individual granted authority to use the system is falsely rejected by the system. An aggregate measure of type-I error rates is the failure-to-enroll rate (FER), the proportion of people who fail to be enrolled successfully. The other, referred to as the false-acceptance rate (FAR), or type-II error rate, is the number of times an individual not granted authority to use a system is falsely accepted by the system. Each biometric system may be adjusted to lower FRR or FAR, but as a general rule when one decreases, the other increases (and vice versa), and there is an adjustment point where the two errors are equal. An overall metric related to the two error types is the equal error rate (EER), which is the percent showing when false rejection and acceptance are equal. The lower the overall measure the more effective the biometric.

PHYSICALLY ORIENTED BIOMETRICS
Generally, the ordering of biometric devices with the best response times and lowest EERs are palm, hand, iris, retina, fingerprint and voice, respectively.

Palm-based biometric devices analyze physical characteristics associated with the palm such as ridges and valleys. This biometric involves placing the hand on a scanner where physical characteristics are captured.

As one of the oldest biometric techniques, **hand geometry** is concerned with measuring the physical characteristics of the users' hands and fingers from a three-dimensional perspective. The user places his hand, palm-down, on a metal surface with five guidance pegs to ensure that fingers are placed properly and in the correct hand position. The template is built from measurements of physical geometric characteristics of a person's hand (usually 90 measurements)—for example, length, width, thickness and surface area.

Advantages of these systems are the social acceptance that they have received as well as the very little computer storage space that is required for the template, generally 10 to 20 bytes. The main disadvantage compared to other biometrics methods is the lack of uniqueness of hand geometry data. Moreover, an injury to the hand may cause the measurements to change, resulting in recognition problems.

An **iris**, which has patterns associated with the colored portions surrounding the pupils, is unique for every individual and, therefore, a viable method for user identification. To capture this information, the user is asked to center his/her eye onto a device by seeing the reflection of their iris in the device. Upon this alignment occurring, a camera takes a picture of the user's iris and compares it with a stored image. The iris is stable over time, having over 400 characteristics, although only approximately 260 of these are used to generate the template. As is the case with fingerprint scanning, the template carries less information than a high-quality image.

The key advantage to iris identification is that contact with the device is not needed, which contrasts with other forms of identification such as fingerprint and retinal scans. Disadvantages of iris recognition are the high cost of the system, as compared to other biometric technologies, and the high amount of storage requirements needed to uniquely identify a user.

Retina scan uses optical technology to map the capillary pattern of the eye's retina. The user has to put his eye within 0.4 to 0.8 inches (1 to 2 cm) of the reader while an image of the pupil is taken. The patterns of the retina are measured at over 400 points to generate a 96-byte template. Retinal scan is extremely reliable, and it has the lowest FAR among the current biometric methods. Disadvantages of retinal scanning include the need for fairly close physical contact with the scanning device, which impairs user acceptance, and the high cost.

Fingerprint access control is commonly used; the user places his/her finger on an optical device or silicon surface to get his/her fingerprint scanned. The template generated for the fingerprint, named "minutiae," measures bifurcations, divergences, enclosures, endings and valleys in the ridge pattern. It contains only specific data about the fingerprint (the minutiae), not the whole image of the fingerprint itself. Additionally, the full fingerprint cannot be reconstructed from the template. Depending on the provider, the fingerprint template may use between 250 bytes to more than 1,000 bytes. More storage space implies lower error rates. Fingerprint characteristics are described by a set of numeric values. While the user puts the finger in place for between two and three seconds, a typical image containing between 30 and 40 finger details is obtained and an automated comparison to the user's template takes place.

Advantages of fingerprint scanning are low cost, small size of the device, ability to physically interface into existing client-server–based systems, and ease of integration into existing access control methods. Disadvantages include the need for physical contact with the device and the possibility of poor-quality

images due to residues, such as dirt and body oils, on the finger. Additionally, fingerprint biometrics are not as effective as other techniques.

In **face-recognition biometric** devices, the biometric reader processes an image captured by a video camera, which is usually within 24 inches (60 cm) of the human face, isolating it from the other objects captured within the image. The reader analyzes images captured for general facial characteristics. The template created is based on either generating two- or three-dimensional mapping arrays or by combining facial-metric measurements of the distance between specific facial features, such as the eyes, nose and mouth. Some vendors also include thermal imaging in the template.

The face is considered to be one of the most natural and most "friendly" biometrics, and it is acceptable to users because it is fast and easy to use. The main disadvantage of face recognition is the lack of uniqueness, which means that people who look alike may fool the device. Moreover, some systems cannot maintain high levels of performance as the database grows in size.

BEHAVIOR-ORIENTED BIOMETRICS

In **signature recognition**, also referred to as signature dynamics, the information from the reader is used to analyze two different areas of an individual's signature: the specific features of the signature and the specific features of the signing process. It includes speed, pen pressure, directions, stroke length and the points in time when the pen is lifted from the paper.

Advantages of this method are that it is fast, easy to use and has a low implementation cost. Other advantages are that even though a person might be able to duplicate the visual image of someone else's signature, it is difficult if not impossible to duplicate the dynamics (e.g., time duration in signing, pen-pressure, how often pen leaves signing block, etc.).

The main disadvantage is capturing the uniqueness of a signature particularly when a user does not sign his/her name in a consistent manner. For example this may occur due to illness/disease or use of initials versus a complete signature. Additionally, users' signing behavior may change when signing onto signature identification and authentication "tablets" versus writing the signature in ink onto a piece of paper.

Voice recognition involves taking the acoustic signal of a person's voice, saying a "passphrase," and converting it to a unique digital code that can then be stored in a template (approximately 1,500 to 3,000 bytes). Voice recognition incorporates several variables or parameters to recognize one's voice/speech pattern including pitch, dynamics and waveform.

The main attraction of this method is that it can be used for telephone applications, where it can be deployed with no additional user hardware costs. It also has a high rate of acceptance among users.

Disadvantages of this method include:
- The large volume of storage requirements
- Changes to people's voices
- The possibility of misspoken phrases
- A clandestine recording of the user's voice saying the passphrase could be made and played back to gain access.
- Background noises can interfere with the system.

MANAGEMENT OF BIOMETRICS

Management of biometrics should address effective security for the collection, distribution and processing of biometric data, encompassing:
- Data integrity, authenticity and nonrepudiation
- Management of biometric data across its life cycle—comprised of the enrollment, transmission, storage, verification, identification and termination processes
- Use of biometric technology, including one-to-one and one-to-many matching, for the identification and authentication of its users
- Application of biometric technology for internal and external, as well as logical and physical, access control
- Encapsulation of biometric data
- Techniques for the secure transmission and storage of biometric data
- Security of the physical hardware used throughout the biometric data life cycle
- Techniques for integrity and privacy protection of biometric data

Management should develop and approve a biometric information management and security (BIMS) policy. The auditor should use the BIMS policy to gain a better understanding of the biometric systems in use. With respect to testing, the auditor should make sure this policy has been developed and the biometric information is being secured appropriately.

As is the case with any critical information system, logical and physical controls including business continuity plans should address this area.

Life cycle controls for the development of biometric solutions should be in place to cover the enrollment request, the template creation and storage, and the verification and identification procedures. The identification and authentication procedures for individual enrollment and template creation should be specified in the BIMS policy. Management needs to have controls in place to ensure that these procedures are being followed in accordance with this policy. If the biometric device malfunctions or is inoperable, backup authentication methods should also be developed. Controls should also be in place to protect the sample data as well as the template from modification during transmission.

Single Sign-on

Users normally require access to a number of resources during the course of their daily routine. For example, users would first log into an OS and thereafter into various applications. For each OS application or other resource in use, users are required to provide a separate set of credentials to gain access. This can result in a situation where users' ability to remember passwords is significantly reduced. This also increases the chance that users will write them down on or near their workstation or area of work, thereby increasing the risk of a security breach within the organization. To address this situation, the concept of single sign-on (SSO) was developed. SSO is defined as the process for consolidating all organization platform-based administration, authentication and authorization functions into a single centralized administrative function. This function would provide the appropriate interfaces to the organization's information resources, which may include:
- Client-server and distributed systems
- Mainframe systems
- Network security including remote access mechanisms

The SSO process begins with the first instance where the user credentials are introduced into the organization's IT computing environment. The information resource or SSO server handling this function is referred to as the primary domain. Every other information resource, application or platform that uses those credentials is called a secondary domain.

The challenges in managing diverse platforms through SSO principally involve overcoming the heterogeneous nature of diverse networks, platforms, databases and applications often found in organizations when establishing a set of credentials acceptable to all of these information resources. To effectively integrate into the SSO process, SSO administrators need to obtain an understanding of how each system manages credentialing information, access control list (ACL) authorization rules, and audit logs and reports. Requirements developed in this regard should be based on security domain policies and procedures.

SSO advantages include:

- Multiple passwords are no longer required; therefore, a user may be more inclined and motivated to select a stronger password.
- It improves an administrator's ability to manage users' accounts and authorizations to all associated systems.
- It reduces administrative overhead in resetting forgotten passwords over multiple platforms and applications.
- It reduces the time taken by users to log into multiple applications and platforms.

SSO disadvantages include:

- Support for all major OS environments is difficult. SSO implementations will often require a number of solutions integrated into a total solution for an enterprise's IT architecture.
- The costs associated with SSO development can be significant when considering the nature and extent of interface development and maintenance that may be necessary.
- The centralized nature of SSO presents the possibility of a single point of failure and total compromise of an organization's information assets. For this reason, strong authentication in the form of complex password requirements and the use of biometrics is frequently implemented.

One example of SSO is Kerberos. Created by the Massachusetts Institute of Technology, it is an authentication service used to validate services and users in a distributed computing environment (DCE). The role of the authentication service is to allow principals to positively identify themselves and participate in a DCE. Both users and servers authenticate themselves in a DCE environment, unlike security in most other client-server systems where only users are authenticated. There are two distinct steps to authentication. At initial logon time, the Kerberos third-party protocol is used within DCE to verify the identity of a client requesting to participate in a DCE network. This process results in the client obtaining credentials initially registered with the trusted third party and cryptographically protected. These credentials form the basis for setting up secure sessions with DCE servers when the user tries to access resources.

SSO can also be addressed using the Security Assertion Markup Language (SAML). This is open standard data format using XML to exchange authentication and authorization information between services. The single most important requirement that SAML addresses is web browser SSO.

5.3.6 AUTHORIZATION ISSUES

The authorization process used for access control requires that the system be able to identify and differentiate among users.

Access rules (authorization) specify who can access what. For example, access control is often based on least privilege, which refers to the granting to users of only those accesses required to perform their duties. Access should be on a documented need-to-know and need-to-do basis by type of access.

Computer access can be set for various levels (i.e., files, tables, data items, etc.). When IS auditors review computer accessibility, they need to know what can be done with the access and what is restricted. For example, access restrictions at the file level generally include the following:
- Read, inquiry or copy only
- Write, create, update or delete only
- Execute only
- A combination of the above

The least dangerous type of access is read only, as long as the information being accessed is not sensitive or confidential. This is because the user cannot alter or use the computerized file beyond basic viewing or printing.

Access Control Lists

To provide security authorizations for the files and facilities listed previously, logical access control mechanisms utilize access authorization tables, also referred to as access control lists (ACLs) or access control tables. ACLs refer to a register of:
- Users (including groups, machines, processes) who have permission to use a particular system resource
- The types of access permitted

ACLs vary considerably in their capability and flexibility. Some only allow specifications for certain preset groups (e.g., owner, group and world), while more advanced ACLs allow much more flexibility such as user-defined groups. Also, more advanced ACLs can be used to explicitly deny access to a particular individual or group. With more advanced ACLs, access can be at the discretion of the policy maker (and implemented by the security administrator) or individual user, depending upon how the controls are technically implemented. When a user changes job roles within an organization, often their old access rights are not removed before adding their new required accesses. Without removing the old access rights, there could be a potential SoD issue.

Logical Access Security Administration

In today's client-server environment, the access identification and authentication, and the authorization process, can be administered either through a centralized or decentralized environment. The advantages of conducting security in a decentralized environment are:
- The security administration is onsite at the distributed location.
- Security issues are resolved in a timely manner.
- Security controls are monitored on a more frequent basis.

The risk associated with distributed responsibility for security administration includes:
- Local standards might be implemented rather than those required by the organization
- Levels of security management might be below what can be maintained by a central administration
- Unavailability of management checks and audits that are often provided by central administration to ensure that standards are maintained

There are many ways to control remote and distributed sites:
- Software controls over access to the computer, data files and remote access to the network should be implemented.
- The physical control environment should be as secure as possible, with additions such as lockable terminals and a locked computer room.
- Access from remote locations via modems and laptops to other microcomputers should be controlled appropriately.
- Opportunities for unauthorized people to gain knowledge of the system should be limited by implementing controls over access to system documentation and manuals.
- Controls should exist for data transmitted from remote locations such as sales in one location that update accounts receivable files at another location. The sending location should transmit control information, such as transaction control totals, to enable the receiving location to verify the update of its files. When practical, central monitoring should ensure that all remotely processed data have been received completely and updated accurately.
- When replicated files exist at multiple locations, controls should ensure that all files used are correct and current and, when data are used to produce financial information, that no duplication arises.

Remote Access Security

Remote access connectivity to their information resources is required for many organizations for different types of users, such as employees, vendors, consultants, business partners and customer representatives. In providing this capability, a variety of methods and procedures are available to satisfy an organization's business need for this level of access.

Remote access users can connect to their organization's networks with the same level of functionality that exists within their office. In doing so, the remote access design uses the same network standards and protocols applicable to the systems that they are accessing, Transmission Control Protocol/Internet Protocol (TCP/IP)-based systems and systems network architecture (SNA) systems, for the mainframe where the user uses terminal emulation software to connect to a mainframe-based legacy application. Support for these connections includes asynchronous point-to-point modem connectivity, integrated services digital network (ISDN) dial-on-demand connectivity, and dedicated lines (e.g., frame relay and digital subscriber lines [DSL]).

COMMON CONNECTIVITY METHODS

TCP/IP Internet-based remote access is a cost-effective approach that enables organizations to take advantage of the public network infrastructures and connectivity options available, under which ISPs manage modems and dial-in servers, and DSL and cable modems reduce costs further to an organization. To effectively use this option, organizations establish a virtual private network over the Internet to securely communicate data packets over this public infrastructure. Available VPN technologies apply the Internet Engineering Task Force (IETF) IPSec standard (see section 5.4.5 Encryption for more details on IPSec). Advantages are their ubiquity, ease of use, inexpensive connectivity, and read, inquiry or copy only access. Disadvantages include that they are significantly less reliable than dedicated circuits, lack a central authority, and can be difficult to troubleshoot.

Organizations should be aware that using VPNs to allow remote access to their systems can create holes in their security infrastructure. The encrypted traffic can hide unauthorized actions or malicious software that can be transmitted through such channels. IDSs and virus scanners able to decrypt the traffic for analysis and then encrypt and forward it to the VPN endpoint should be considered as preventive controls. A good practice will terminate all VPNs to the same endpoint in a so called VPN concentrator, and will not accept VPNs directed at other parts of the network.

A less common method is to use dial-up lines (modem asynchronous point-to-point or ISDN) in accessing an organization's network access server (NAS) that works in concert with an organization's network firewall and router configuration. The NAS handles user authentication, access control and accounting, while maintaining connectivity. The most common protocol for doing this is the Remote Access Dial-in User Service (RADIUS) and Terminal Access Controller Access Control System (TACACS). In a typical NAS implementation, calls into the network are received, and as a good security practice, the call is terminated after recording the calling number and performing preliminary authentication procedures. The standard security practice has been for the NAS to initiate a call back to a predetermined number of the user. This control can be circumvented through effective implementation of call-forwarding mechanisms.

Dial-up connectivity, not based on centralized control and least preferred from a security and control standpoint, is an organization's server whose OS is set up to accept remote access, which is referred to as a remote access server (RAS). The latter approach is not recommended, as it is extremely difficult to control remote access from many servers using its own RAS capability.

Advantages of dial-up connectivity are its low end-user costs (local phone calls) and that it is intuitive and easy to use (familiarity). Disadvantages are related to performance; for example, reliability in establishing connections with the NAS (phone networks' electrical interference) and time-sensitive media-rich applications or a service's failure when data-rate throughput is low.

Another common connectivity method often used for remote access is dedicated network connections. Using private, often proprietary, network circuits is the approach generally considered the safest because the only network traffic carried belongs to the same organization. It is commonly used by branch/regional offices or with business partners.

Advantages of dedicated network connections include greater performance gains in data throughput and reliability, and data on a dedicated link belonging to the subscribing organization, where an intruder would have to compromise the telecommunications provider itself to access the data link. A disadvantage is that cost is typically two- to five-times higher than connections to the Internet.

Remote access risk includes:
- DoS where remote users may not be able to gain access to data or applications that are vital for them to carry out their day-to-day business
- Malicious third parties; these may gain access to critical applications or sensitive data by exploiting weaknesses in communications software and network protocols
- Misconfigured communications software, which may result in unauthorized access or modification of an organization's information resources
- Misconfigured devices on the corporate computing infrastructure
- Host systems not secured appropriately, which could be exploited by an intruder gaining access remotely
- Physical security issues over remote users' computers

Remote access controls include:
- Policy and standards
- Proper authorizations
- Identification and authentication mechanisms
- Encryption tools and techniques such as use of a VPN
- System and network management

Audit Logging in Monitoring System Access
Most access control software has security features that enable a security administrator to automatically log and report all levels of access attempts—successes and failures. For example, access control software can log computer activity initiated through a logon ID or computer terminal. This information provides management an audit trail to monitor activities of a suspicious nature, such as a hacker attempting brute force attacks on a privileged logon ID. Also, keystroke logging can be turned on for users that have sensitive access privileges. What is logged is determined by the action of the organization. Issues include what is logged, who/what has access to the logs and how long logs are retained (record-retention item).

ACCESS RIGHTS TO SYSTEM LOGS
Access rights to system logs for security administrators to perform the above activities should be strictly controlled.

Computer security managers and system administrators/managers should have access for review purposes; however, security and/or administration personnel who maintain logical access functions may not need to access audit logs.
It is particularly important to ensure the integrity of audit trail data against modification. This can be done using digital signatures, write-once devices or a security information and event management (SIEM) systems. The audit trail files need to be protected because intruders may try to cover their tracks by modifying audit trail records. Audit trail records should be protected by strong access controls to help prevent unauthorized access. The integrity of audit trail information may be particularly important when legal issues arise, such as the use of audit trails as legal evidence. (This may, for example, require daily printing and signing of the logs.) Questions regarding such legal issues should be directed to the appropriate legal counsel.

The confidentiality of audit trail information may also be protected if the audit trail is recording information about users that may be disclosure-sensitive, such as transaction data containing personal information (e.g., before and after records of modification to income tax data). Strong access controls and encryption can be particularly effective in preserving confidentiality.

Media logging is used to support accountability. Logs can include control numbers (or other tracking data) such as the times and dates of transfers, names and signatures of individuals involved, and other relevant information. Periodic spot checks or audits may be conducted to determine that no controlled items have been lost and that all are in the custody of individuals named in control logs. Automated media tracking systems may be helpful for maintaining inventories of tape and disk libraries.

A periodic review of system-generated logs can detect security problems, including attempts to exceed access authority or gain system access during unusual hours. Certain reports are generated for security recorded in activity logs.

TOOLS FOR AUDIT TRAIL (LOGS) ANALYSIS
Many types of tools have been developed to help reduce the amount of information contained in audit records and to delineate useful information from the raw data.

On most systems, audit trail software can create large files, which can be extremely difficult to analyze manually. The use of automated tools is likely to be the difference between unused audit trail data and an effective review. Some of the types of tools include:
- **Audit reduction tools**—They are preprocessors designed to reduce the volume of audit records to facilitate manual review. Before a security review, these tools can remove many audit records known to have little security significance. (This alone may cut in half the number of records in the audit trail.) These tools generally remove records generated by specified classes of events—for example, records generated by nightly backups might be removed.
- **Trend/variance-detection tools**—They look for anomalies in user or system behavior. It is possible to construct more sophisticated processors that monitor usage trends and detect major variations. For example, if a user typically logs in at 09:00 but appears at 04:30 one morning, this may indicate a security problem that may need to be investigated.
- **Attack-signature-detection tools**—They look for an attack signature, which is a specific sequence of events indicative of an unauthorized access attempt. A simple example would be repeated failed logon attempts.
- **SIEM systems**—These tools capture audit trails or logs and perform real-time analysis on them. They can aggregate audit trails and logs from many different sources. These data can then be correlated and alerts provided if required. Some SIEM systems can also be configured to perform automated tasks based upon the alerts (e.g., launching a vulnerability scan or commanding the firewall to close a certain port).

COST CONSIDERATIONS
Audit trails involve many costs that factor into IT's determination as to how much logging is enough. First, some system overhead is incurred while recording the audit trail. Additional system overhead will be incurred to store and process the records. The more detailed the records, the more overhead is required. In some systems, logging every event could cause the system to lock up or slow to the point at which response time would be measured in minutes. Obviously, this is not acceptable if IT is to be properly aligned with the needs of the business. Another cost involves human and machine time required when performing the analysis. This can be minimized by using tools to perform most of the analysis. Many simple analyzers can be constructed quickly and inexpensively from system utilities, but they are limited to audit reduction and the identification of particularly sensitive events. More complex tools such as SIEM systems will be more expensive both to purchase and to implement.

The final cost of audit trails is the cost of investigating unexpected and anomalous events. If the system is identifying too many events as suspicious, administrators may spend undue time reconstructing events and questioning personnel.

The frequency of the security administrator's review of computer access reports should be commensurate with the sensitivity of the computerized information being protected. The IS auditor should ensure that the logs cannot be tampered with, or altered, without leaving an audit trail.

When reviewing or performing security access follow-up, the IS auditor should look for:
- Patterns or trends that indicate abuse of access privileges, such as concentration on a sensitive application
- Violations (such as attempting computer file access that is not authorized) and/or use of incorrect passwords

Once a violation has been identified:
- The person who identified the violator should refer the problem to the security administrator for investigation.
- The security administrator and responsible management should work together to investigate and determine the severity of the violation. Generally, most violations are accidental.
- If a violation attempt is serious, executive management should be notified, not law enforcement officials. Executive management normally is responsible for notifying law enforcement officials. Involvement of external agencies may result in adverse publicity that is ultimately more damaging than the original violation; therefore, the decision to involve external agencies should be left to executive management.
- Procedures should be in place to manage public relations and the press.
- To facilitate proper handling of access violations, written guidelines should exist that identify various types and levels of violations and how they will be addressed. This effectively provides direction for judging the seriousness of a violation.
- Disciplinary action should be a formal process that is applied consistently. This may involve a reprimand, probation or immediate termination. The procedures should be legally and ethically sound to reduce the risk of legal action against the company.
- Corrective measures should include a review of the computer access rules, not only for the perpetrator but for interested parties. Excessive or inappropriate access rules should be eliminated.

Naming Conventions for Logical Access Controls
Access capabilities are implemented by security administration in a set of access rules that stipulates which users (or groups of users) are authorized to access a resource (such as a dataset or file) and at what level (such as read or update). The access control mechanism applies these rules whenever a user attempts to access or use a protected resource.

Access control naming conventions are structures used to govern user access to the system and user authority to access/use computer resources such as files, programs and terminals. These general naming conventions and associated files are required in a computer environment to establish and maintain personal accountability and SoD in the access of data. The owners of the data or application, with the help of the security officer, usually set up naming conventions. The need for sophisticated naming conventions over access controls depends on the importance and level of security that is needed to ensure that unauthorized access has not been granted. It is important to establish naming conventions that both promote the implementation of efficient access rules and simplify security administration.

Naming conventions for system resources (e.g., as datasets, volumes, programs and employees workstations) are an important prerequisite for efficient administration of security controls. Naming conventions can be structured so that resources beginning with the same high-level qualifier can be governed by one or more generic rule(s). This reduces the number of rules required to adequately protect resources which, in turn, facilitates security administration and maintenance efforts.

5.3.7 STORING, RETRIEVING, TRANSPORTING AND DISPOSING OF CONFIDENTIAL INFORMATION
Management should define and implement procedures to prevent access to, or loss of, sensitive information and software from computers, disks, and other equipment or media when they are stored, disposed of or transferred to another user.

This should be done for the following:

- **Backup files of databases**—Backup files on magnetic tapes are often unencrypted, so that even confidential information may be obtained by simply transferring backup databases to other systems for data analysis. Security problems of data media storage and transportation technologies involve ensuring that contractors used to transport and store backup tapes have adequate policies and procedures to protect the integrity and confidentiality of the information. It is good practice to fully encrypt all portable or backup media.
- **Data banks**—Research and commercial institutions collect the results of important survey or research projects on large tapes. These data have a high commercial value and may be subject to a requirement of availability and confidentiality that persist for many years, longer than the duration of the media containing them. Preserving the value requires precautions and possibly a planned media verification or duplication activity. In general, a solution is required to the problems of long-term computer storage of sensitive information. Optical disks are a possible medium, but their durability and standardization should be evaluated.
- **Disposal of media previously used to hold confidential information**—Procedures should be implemented to identify and erase the sensitive information and software inside computers, disks and other equipment or media that have been identified for disposal so that deleted data may not be retrieved by any internal or third party. Care must be taken not only to meet the requirements of data protection, but also when a machine is transferred to another user. The original user should remove any personal data that are confidential by nature. If previously held data were sensitive, the disk should be reformatted and then a secure wipe of the disk should be carried out to a defined standard.
  - In some cases, when information is highly confidential, it may prove insufficient to wipe the media. Random access memory (RAM) is included because favorable circumstances and appropriate technical analysis of these media could expose the data. This may require that such equipment or media should be disposed of in a secure manner (e.g., destruction). This may include “degaussing” (demagnetizing) the magnetic media, such as tapes or PC hard drives, and possibly their physical destruction.
- **Management of equipment sent for offsite maintenance**—Data files and proprietary software should be backed up, so that they can be erased from the equipment prior to sending it offsite for maintenance (e.g., computers, tablets, flash drives). Computers holding confidential data should not be sent out for repair, unless memories are withheld.
- **Public agencies and organizations concerned with sensitive, critical or confidential information**—These organizations may have particular obligations to develop a comprehensive records management program. Policies addressing these needs should reflect laws concerning availability, substance, degree of confidentiality and disposal compared to available technical solutions and organizational needs. For instance, public records may be destroyed only in accordance with precise record-retention schedules, and the record holder may not mutilate, destroy, sell, loan or otherwise dispose of any record, except under a record-retention schedule or with the written consent of the owner. Proper record retention requires the preparation of separate retention schedules depending on subject files (administrative vs. other legal requirements).
- **E-token electronic keys**—For such sensitive information, data transportation on removable media is not safe, and taking proper care of the media can significantly reduce the chances of data loss.
- **Storage records**—Many commercial organizations fulfill legal or institutional obligations to preserve specific types of records, which may be confidential in nature, for a given number of years. In some cases these obligations are fulfilled by preserving database images and the source of the documents, either online or on backup tapes. In these cases, the conditions of recreating the original document must be integrally retained as well.

Preserving Information During Shipment or Storage

Manufacturers publish recommended temperature and humidity levels in which to store media. These recommendations should be consulted and adhered to before storing or shipping important media. However, some general tips can be followed to help avoid potential damage to media during shipping and storage. The following environmental issues are applicable to all types of media:

- Keep out of direct sunlight.
- Keep free of dust.
- Keep free of liquids.
- Minimize exposure to magnetic fields, radio equipment or any sources of vibration.
- Do not air transport in areas and at times of exposure to a strong magnetic storm.

Media-specific Storage Precautions

Some precautions need to be considered regarding media-specific storage (see **figure 5.13**).

Figure 5.13—Media-specific Storage Precautions

Media Storage	Precautions
Hard drives	• Store hard drives in antistatic bags, and be sure that the person removing them from the bag is static-free. • If the original box and padding for the hard drive is available, use it for shipping. • Avoid Styrofoam packaging products or other materials that can cause static electricity. • Quick drops or spikes in temperature are a danger, because such changes can lead to hard drive crashes. • If the hard drive has been in a cold environment, bring it to room temperature prior to installing and using it. • Avoid sudden mechanical shocks or vibrations.
Tape cartridges	• Store cartridges vertically. • Store cartridges in protective containers for transport. • Write-protect cartridges immediately.
USB, flash and portable hard drives	• Avoid temperature and humidity extremes and strong magnetic fields.
CDs and DVDs	• Handle by the edges or by the hole in the middle. • Be careful not to bend the media. • Avoid long-term exposure to bright light. • Store in a hard jewel case, not in soft sleeves.

5.4 NETWORK INFRASTRUCTURE SECURITY

Communication networks (wide area or local area networks) generally include devices connected to the network as well as programs and files supporting the network operations. Control is accomplished through a network control terminal and specialized communications software.

The following are controls over the communication network:

- Network control functions should be performed by individuals possessing adequate training and experience.

- Network control functions should be separated, and the duties should be rotated on a regular basis, where possible.
- Network control software must restrict operator access from performing certain functions (e.g., the ability to amend/delete operator activity logs).
- Network control software should maintain an audit trail of all operator activities.
- Audit trails should be periodically reviewed by operations management to detect any unauthorized network operations activities.
- Network operation standards and protocols should be documented and made available to the operators and should be reviewed periodically to ensure compliance.
- Network access by the system engineers should be monitored and reviewed closely to detect unauthorized access to the network.
- Analysis should be performed to ensure workload balance, fast response time and system efficiency.
- A terminal identification file should be maintained by the communications software to check the authentication of a terminal when it tries to send or receive messages.
- Data encryption should be used, where appropriate, to protect messages from disclosure during transmission.
- Restrictions should be placed on remote printing facilities to ensure sensitive documents cannot be read by unauthorized personnel.

To improve the control and maintenance of the infrastructure and its use, besides the direct management of the network devices, consolidate the logs of these devices with the firewall's logs and the client-server OS's logs.

In recent years, the management of large capacity storage units is frequently based on fiber channel connections.

Systems security is improved when a dynamic inventory of the devices is possible. In the case of an incident, it is important to know which computer is used by whom.

Another important security improvement is the ability to identify users at every step of their activity. Some application packages use predefined names (e.g., SYSTEM). New monitoring tools have been developed to resolve this problem.

Adopting an IT governance practice enables an organization to comply with network security requirements effectively. The Information Technology Infrastructure Library (ITIL) is a framework of practice guidance in information technology service management that can be used in setting up service level agreements (SLAs), specifically for enterprise network operations, to maintain the uninterrupted operation of the network through controls, incident handling and auditing (see chapter 4 IS Operations, Maintenance and Service Management).

5.4.1 LAN SECURITY

LANs are computer networks that cover a limited area such as a home, office or campus. The security of a LAN is dependent on the security of its component parts.

As LANs facilitate the storage and retrieval of programs and data used by a group of people, the security of the LAN is also dependent on the security of the OS.

For more information on risk associated with networks and OSs, see chapter 4 IS Operations, Maintenance and Service Management.

Risk associated with use of LANs includes:
- Loss of data and program integrity through unauthorized changes
- Lack of current data protection through inability to maintain version control
- Exposure to external activity through poor user verification and potential public network access from remote connections
- Virus and worm infection
- Improper disclosure of data because of general access rather than need-to-know access provisions
- Illegal access by impersonating or masquerading as a legitimate LAN user
- Internal user's sniffing (obtaining seemingly unimportant information from the network that can be used to launch an attack such as network address information)
- Internal user's spoofing (reconfiguring a network address to pretend to be a different address)
- Lack of enabled detailed automated logs of activity (audit trails)
- Destruction of the logging and auditing data

The LAN security provisions available depend on the software product, product version and implementation. Commonly available network security administrative capabilities include:
- Declaring ownership of programs, files and storage
- Limiting access under the principle of least privilege (users can only access what they need to perform their role)
- Implementing record and file locking to prevent simultaneous update
- Enforcing user ID/password sign-on procedures, including the rules relating to password length, format and change frequency
- Using switches to implement port security policies rather than hubs or non-manageable routers. This will prevent unauthorized hosts, with unknown MAC addresses, to connect to the LAN.
- Encrypting local traffic using IPSec protocol

To gain a full understanding of the LAN, the IS auditor should identify and document the following:
- Users or groups with privileged access rights
- LAN topology and network design
- LAN administrator/LAN owner
- Functions performed by the LAN administrator/owner
- Distinct groups of LAN users
- Computer applications used on the LAN
- Procedures and standards relating to network design, support, naming conventions and data security

Virtualization

Virtualization provides an enterprise with a significant opportunity to increase efficiency and decrease costs in its IT operations. However, virtualization also introduces additional risk. IS auditors need to understand the advantages and disadvantages of virtualization to determine whether the enterprise has

considered the applicable risk in its decision to adopt, implement and maintain this technology.

At a high level, virtualization allows multiple OSs (guests) to coexist on the same physical server (host) in isolation of one another. Virtualization creates a layer between the hardware and the guest OSs to manage shared processing and memory resources on the host. Often, a management console provides administrative access to manage the virtualized system. **Figure 5.14** summarizes several advantages and disadvantages of virtualization.

Figure 5.14—Advantages and Disadvantages of Virtualization

Advantages	Disadvantages
• Server hardware costs may decrease for both server builds and server maintenance. • Multiple OSs can share processing capacity and storage space that often goes to waste in traditional servers, thereby reducing operating costs. • The physical footprint of servers may decrease within the data center. • A single host can have multiple versions of the same OS, or even different OSs, to facilitate testing of applications for performance differences. • Creation of duplicate copies of guests in alternate locations can support business continuity efforts. • Application support personnel can have multiple versions of the same OS, or even different OSs, on a single host to more easily support users operating in different environments. • A single machine can house a multitier network in an educational lab environment without costly reconfigurations of physical equipment. • Smaller organizations that had performed tests in the production environment may be better able to set up logically separate, cost-effective development and test environments. • If set up correctly, a well-built, single access control on the host can provide tighter control for the host's multiple guests.	• Inadequate configuration of the host could create vulnerabilities that affect not only the host, but also the guests. • Exploits of vulnerabilities within the host's configuration, or a denial of service attack against the host, could affect all of the host's guests. • A compromise of the management console could grant unapproved administrative access to the host's guests. • Performance issues of the host's own OS could impact each of the host's guests. • Data could leak between guests if memory is not released and allocated by the host in a controlled manner. • Insecure protocols for remote access to the management console and guests could result in exposure of administrative credentials.

Although virtualization offers significant advantages, they come with risk that an enterprise must manage effectively. Because the host in a virtualized environment represents a potential single point of failure within the system, a successful attack on the host could result in a compromise that is larger in both scope and impact.

To address risk, an enterprise can often implement and adapt the same principles and good practices for a virtualized server environment that it would use for a server farm. These include the following:
- Strong physical and logical access controls, especially over the host and its management console
- Sound configuration management practices and system hardening for the host, including patching, antivirus, limited services, logging, appropriate permissions and other configuration settings
- Appropriate network segregation, including the avoidance of virtual machines in the demilitarized zone (DMZ) and the placement of management tools on a separate network segment
- Strong change management practices

5.4.2 CLIENT-SERVER SECURITY

A client-server is a network architecture in which each computer or process on the network is either a server (a source of services and data) or a client (a user of these services and data that relies on servers to obtain them). Client-server architectures can be two-tiered (includes the use of a thick client), three-tiered (includes the use of application servers and a thin client, probably a browser) or n-tiered (includes multiple applications servers, middleware, etc.).

The security of a client-server environment is dependent on the security of its component parts. This includes the security of the:
- LAN
- Client
- OS
- Database
- Middleware

In a client-server environment, several access routes exist, because application data may exist on the server or on the client. Therefore, each of these routes must be examined individually and in relation to each other to ensure that no exposures are left unchecked.

An additional risk to consider with the client-server model is the potential gaps between the components. In other words, how do the components connect to each other?

For example, in a two-tiered environment, the thick client must connect to the database. To achieve this, either (1) every user has a database account, in which case they may be able to bypass the client application (and hence the application controls) and connect directly to the database or (2) a proxy user (i.e., a single account that connects to the database on behalf of all others) is used, in which case the database password must be stored somewhere. This might be stored insecurely or unencrypted.

In a client-server environment the IS auditor should ensure that:
- Application controls cannot be bypassed.
- Passwords are always encrypted.
- Access to configuration or initialization files is kept to a minimum.
- Access to configuration or initialization files are audited.

Note: The IS auditor should be familiar with risk and exposures related to network infrastructure.

5.4.3 WIRELESS SECURITY THREATS AND RISK MITIGATION

The classification of security threats may be segmented into nine categories:
- Errors and omissions
- Fraud and theft committed by authorized or unauthorized users of the system
- Employee sabotage
- Loss of physical and infrastructure support
- Malicious hackers
- Industrial espionage
- Malicious code
- Foreign government espionage
- Threats to personal privacy

All of these represent potential threats in wired networks as well. However, the more immediate concerns for wireless communications are device theft, DoS, malicious hackers, malicious code, theft of service, and industrial and foreign government espionage.

Theft is likely to occur with wireless devices because of their portability. Authorized and unauthorized users of the system may commit fraud and theft; however, authorized users are more likely to carry out such acts. Because users of a system may know what resources a system has and the system's security flaws, it is easier for them to commit fraud and theft.

Malicious hackers, sometimes called crackers, are individuals who break into a system without authorization, usually for personal gain or to do harm. Such hackers may gain access to the wireless network access point by eavesdropping on wireless device communications.

Malicious code involves viruses, worms, Trojan horses, logic bombs or other unwanted software that is intended to damage files or bring down a system. Theft of service occurs when an unauthorized user gains access to the network and consumes network resources. In wireless networks, the unauthorized access threat stems from the relative ease with which eavesdropping can occur on radio transmissions.

Ensuring confidentiality, integrity, authenticity and availability are the prime objectives in wireless networks.

Security requirements include the following:
- **Authenticity**—A third party must be able to verify that the content of a message has not been changed in transit.
- **Nonrepudiation**—The origin or the receipt of a specific message must be verifiable by a third party.
- **Accountability**—The actions of an entity must be uniquely traceable to that entity.
- **Network availability**—The IT resource must be available on a timely basis to meet mission requirements or to avoid substantial losses. Availability also includes ensuring that resources are used only for intended purposes.

Risk in wireless networks is equal to the sum of the risk of operating a wired network plus the new risk introduced by weaknesses in wireless protocols. To mitigate the risk, an organization must adopt security measures and practices that help bring risk to a manageable level.

To date, the list below includes some of the more salient threats and vulnerabilities of wireless systems:
- All the vulnerabilities that exist in a conventional wired network apply to wireless technologies.
- Weaknesses in wireless protocols increase the threat of disclosure of sensitive information. Many wireless networks are either not secure or use outdated encryption algorithms.
- Malicious entities may gain unauthorized access to an agency's computer or voice (IP telephony) network through wireless connections, potentially bypassing any firewall protections.
- Sensitive information that is not encrypted (or that is encrypted with poor cryptographic techniques) and is transmitted between two wireless devices may be intercepted and disclosed.
- DoS attacks may be directed at wireless connections or devices.
- Malicious entities may steal the identity of legitimate users and masquerade as them on internal or external corporate networks.
- Sensitive data may be corrupted during improper synchronization.
- Malicious entities may be able to violate the privacy of legitimate users and track their physical movements.
- Malicious entities may deploy unauthorized equipment (e.g., client devices and access points) to surreptitiously gain access to sensitive information.
- Mobile devices are easily stolen and can reveal sensitive information.
- Data may be extracted without detection from improperly configured devices.
- Viruses or other malicious code may corrupt data on a wireless device and be subsequently introduced to a wired network connection.
- Malicious entities may, through wireless connections, connect to other agencies for the purposes of launching attacks and concealing their activity.
- Interlopers, from inside or out, may be able to gain connectivity to network management controls and thereby disable or disrupt operations.
- Malicious entities may use a third-party, untrusted wireless network service to gain access to the network resources.

Currently, there are many ways that malicious entities may gain access to wireless devices. Those related to WLANs include, but are not limited to, war driving, war walking and war chalking as described in **figure 5.12**.

On the wireless personal area network (WPAN) side, one of the important types of risk is the man-in-the-middle attack as described in **figure 5.12**.

The other problem with WPANs is the uncontrolled propagation of radio waves; for example, the radio traffic on Bluetooth connections can be passively intercepted and recorded using Bluetooth protocol sniffers such as Red Fang, Bluesniff and others. If the device addresses are known, then even if the devices are currently in nondiscoverable mode, it is possible to synchronize to the frequency hopping sequence. All the layers of the Bluetooth protocol stack can be examined and analyzed offline. If encryption is not used, then it is possible to extract and monitor the transmitted user data. Use of an antenna with a strong directional characteristic and electronics capable of amplifying Bluetooth signals can make passive listening attacks possible from a greater distance than the functional range. Transmitting power control is optional and is not supported by every Bluetooth device.

The growing prevalence of people using Bluetooth-enabled equipment may follow the trend of Wi-Fi war driving, in which people try to identify inadequately secured networks by driving around with a laptop.

5.4.4 INTERNET THREATS AND SECURITY

The nature of the Internet makes it vulnerable to attack. The Internet is a global TCP/IP-based system that enables public and private heterogeneous networks to communicate with one another. Around 40 percent of the world's population is connected to the Internet (*www.internetlivestats.com*). Originally designed to allow for the freest possible exchange of information, it is widely used today for commercial purposes. This poses significant security problems for organizations when protecting their information assets. For example, hackers and virus writers try to attack the Internet and computers connected to the Internet. Some want to invade others' privacy and attempt to crack into databases of sensitive information or sniff information as it travels across Internet routes. Consequently, it becomes more important for IS auditors to understand the risk and security factors that are needed to ensure that proper controls are in place when a company connects to the Internet.

The IP is designed solely for the addressing and routing of data packets across a network. It does not guarantee or provide evidence on the delivery of messages; there is no verification of an address; the sender will not know if the message reaches its destination at the time it is required; the receiver does not know if the message came from the address specified as the return address in the packet. Other protocols correct some of these drawbacks.

Network Security Threats
One class of network attacks involves probing for network information. These passive attacks can lead to actual active attacks or intrusions/penetrations into an organization's network. By probing for network information, the intruder obtains network information that can be used to target a particular system or set of systems during an actual attack.

Passive Attacks
Examples of passive attacks that gather network information include network analysis, eavesdropping and traffic analysis as explained in **figure 5.12**.

Active Attacks
Once enough network information has been gathered, the intruder will launch an actual attack against a targeted system to either gain complete control over that system or enough control to cause certain threats to be realized. This may include obtaining unauthorized access to modify data or programs, causing a DoS, escalating privileges, accessing other systems, and obtaining sensitive information for personal gain. These types of penetrations or intrusions are known as active attacks. They affect the integrity, availability and authentication attributes of network security. Common forms of active attacks may include the following (explained in **figure 5.12**):
- Brute force attack
- Masquerading
- Packet replay
- Phishing
- Message modification
- Unauthorized access through the Internet or World Wide Web
- Denial of service (DoS)
- Dial-in penetration attacks
- Email bombing and spamming
- Email spoofing

Causal Factors for Internet Attacks
Generally, Internet attacks of both a passive and active nature occur for a number of reasons including:
- Availability of tools and techniques on the Internet or as commercially available software that an intruder can download easily. For example, to scan ports, an intruder can easily obtain network scanners such as strobe, netcat, jakal, nmap or Asmodeous (Windows). Additionally, password cracking programs such as John the Ripper and L0phtCrack are available free or at a minimal cost.
- Lack of security awareness and training among an organization's employees
- Exploitation of known security vulnerabilities in network- and host-based systems. Many organizations fail to properly configure their systems and to apply security patches or fixes when vulnerabilities are discovered. Most problems can be reduced significantly by keeping network- and host-based systems properly configured and up to date.
- Inadequate security over firewalls and host-based OSs allowing intruders to view internal addresses and use network services indiscriminately

With careful consideration when designing and developing network security controls and supporting processes, an organization can effectively prevent and detect most intrusive attacks on their networks. In this situation, it becomes important for IS auditors to understand the risk and security factors that are needed to ensure proper controls are in place when a company connects to the Internet. There are several areas of control risk that must be evaluated by the IS auditor to determine the adequacy of Internet security controls.

Internet Security Controls
To establish effective Internet security controls, an organization must develop controls within an information systems security framework from which Internet security controls can be implemented and supported. Generally, the process for establishing such a framework entails defining, through corporate policies and procedures, the rules the organization will follow to control Internet usage. For example, one set of rules should address appropriate use of Internet resources with rules that might reserve Internet privileges for those with a business need, define what information resources should be available for outside users, and define trusted and untrusted networks within and outside the organization.

Another set of rules should address the classification of the sensitivity or criticality of corporate information resources. This will help to determine what information will be available for use on the Internet and the level of security to be used for corporate resources of a sensitive or critical nature on the Internet.

From an evaluation of these issues, an organization will be able to develop guidelines specific to their situations for defining the level of security controls related to the confidentiality, integrity and availability of information resources (i.e., business applications) on the Internet. For example, OS security hardening guidelines can be developed which define how the OS should be configured, detail which Internet services should be blocked from use or exploitation by external untrusted users, and define how the system will be protected by firewalls. Additionally, supporting processes over these controls should be defined including:
- Risk assessments performed periodically over the development and redesign of Internet-based web applications
- Security awareness and training for employees, tailored to their levels of responsibilities
- Firewall standards and security to develop and implement firewall architectures
- Intrusion detection standards and security to develop and implement IDS architectures

- Remote access for coordinating and centrally controlling dial-up access on the Internet via corporate resources
- Incident handling and response for detection, response, containment and recovery
- Configuration management for controlling the security baseline when changes do occur
- Encryption techniques applied to protect information assets passing over the Internet
- A common desktop environment to control, in an automated fashion, what is displayed on a user's desktop
- Monitoring Internet activities for unauthorized usage and notification to end users of security incidents via CERT bulletins or alerts

In summary, Internet usage is drastically changing the way business is done and is creating opportunities for organizations to compete in what has become a global virtual market. To compete and survive in this new marketplace, organizations have to go through a paradigm shift in the way they regard security. Security, as it relates to the Internet, will have to be considered an enabler for success and treated as an essential business tool.

Firewall Security Systems

Every time a corporation connects its internal computer network to the Internet, it faces potential danger. Because of the Internet's openness, every corporate network connected to it is vulnerable to attack. Hackers on the Internet could theoretically break into the corporate network and do harm in a number of ways as described previously. Companies should build firewalls as one means of perimeter security for their networks. Likewise, this same principle holds true for sensitive or critical systems that need to be protected from untrusted users inside the corporate network (internal hackers). Firewalls are defined as a device installed at the point where network connections enter a site; they apply rules to control the type of networking traffic flowing in and out. Most commercial firewalls are built to handle the most commonly used Internet protocols.

To be effective, firewalls should allow individuals on the corporate network to access the Internet and, at the same time, stop hackers or others on the Internet from gaining access to the corporate network to cause damage. Generally, most organizations will follow a deny-all philosophy, which means that access to a given resource will be denied unless a user can provide a specific business reason or need for access to the information resource. The converse of this access philosophy, not widely accepted, is the accept-all philosophy under which everyone is allowed access unless someone can provide a reason for denying access.

Firewall General Features

Firewalls are hardware and software combinations that are built using routers, servers and a variety of software. They separate networks from each other and screen the traffic between them. Thus, along with other types of security, they control the most vulnerable point between a corporate network and the Internet, and they can be as simple or complex as the corporate information security policy demands. There are many different types of firewalls, but most enable organizations to:

- Block access to particular sites on the Internet
- Limit traffic on an organization's public services segment to relevant addresses and ports
- Prevent certain users from accessing certain servers or services
- Monitor communications and record communications between an internal and an external network
- Monitor and record all communications between an internal network and the outside world to investigate network penetrations or detect internal subversion
- Encrypt packets that are sent between different physical locations within an organization by creating a VPN over the Internet (i.e., IPSec, VPN tunnels)

The capabilities of some firewalls can be extended so they can also provide for protection against viruses and attacks directed to exploit known OS vulnerabilities.

Firewall Types

Generally, the types of firewalls available today fall into three categories:

- Packet filtering
- Application firewall systems
- Stateful inspection

PACKET FILTERING FIREWALLS

The simplest and earliest kinds of firewalls (i.e., first generation of firewalls) were packet filtering-based firewalls deployed between the private network and the Internet. In packet filtering, a screening router examines the header of every packet of data traveling between the Internet and the corporate network. Information contained in packet headers includes the IP address of the sender and receiver and the authorized port numbers (application or service) allowed to use the information transmitted. Based on that information, the router knows what kind of Internet service, such as web-based or FTP, is being used to send the data as well as the identities of the sender and receiver of the data. Using that information, the router can prevent certain packets from being sent between the Internet and the corporate network. For example, the router could block any traffic except for email or traffic to and from suspicious destinations.

The advantages of this type of firewall are its simplicity and generally stable performance as the filtering rules are performed at the network layer. Its simplicity is also a disadvantage, because it is vulnerable to attacks from improperly configured filters and attacks tunneled over permitted services. Because the direct exchange of packets is permitted between outside systems and inside systems, the potential for an attack is determined by the total number of hosts and services to which the packet filtering router permits traffic. Also, if a single packet filtering router is compromised, every system on the private network may be compromised and organizations with many routers may face difficulties in designing, coding and maintaining the rule base. This means that each host directly accessible from the Internet needs to support sophisticated user authentication and needs to be regularly examined by the network administrator for signs of attack.

Some of the more common attacks against packet filter firewalls are:

- **IP spoofing**—The attacker fakes the IP address of either an internal network host or a trusted network host so that the packet being sent will pass the rule base of the firewall. This allows for penetration of the system perimeter. If the spoofing uses an internal IP address, the firewall can be configured to drop the packet on the basis of packet flow direction analysis. However, if the attacker has access to a secure or trusted external IP address and spoofs on that address, the firewall architecture is defenseless.
- **Source routing specification**—It is possible to define the routing that an IP packet must take when it traverses from the source host to the destination host, across the Internet. In this process, it is possible to define the route so it bypasses the firewall. Only those that know of the IP address, subnet mask and default gateway settings at the firewall routing station can do this. A clear defense against this attack is to examine each packet and, if the source routing specification is enabled, drop that packet. However, if the topology permits a route, skipping the choke point, this countermeasure will not be

effective.

- **Miniature fragment attack**—Using this method, an attacker fragments the IP packet into smaller ones and pushes it through the firewall in the hope that only the first of the sequence of fragmented packets would be examined and the others would pass without review. This is true if the default setting is to pass residual packets. This can be countered by configuring the firewall to drop all packets where IP fragmentation is enabled.

APPLICATION FIREWALL SYSTEMS

There are two types of application firewall systems. They are referred to as application- and circuit-level firewall systems and provide greater protection capabilities than packet filtering routers. Packet filtering routers allow the direct flow of packets between internal and external systems. Application and circuit gateway firewall systems allow information to flow between systems but do not allow the direct exchange of packets. The primary risk of allowing packet exchange between internal and external systems is that the host applications residing on the protected network's systems must be secure against any threat posed by the allowed packets.

Application firewall systems could be an appliance or sit atop hardened (tightly secured) OSs, such as Windows or UNIX. They work at the application level of the Open Systems Interconnection (OSI) model. The application-level gateway firewall is a system that analyzes packets through a set of proxies—one for each service (e.g., Hypertext Transmission Protocol [HTTP] proxy for web traffic, FTP proxy). An HTTP proxy is known as a web application firewall (WAF). This applies rules to HTTP conversations that cover known attacks such as cross-site scripting (XSS) and SQL injection. This kind of work could reduce network performance. Circuit-level firewalls are more efficient and also operate at the application level—where TCP and User Datagram Protocol (UDP) sessions are validated, typically through a single, general-purpose proxy before opening a connection. Commercially, circuit-level firewalls are quite rare.

Both application firewall systems employ the concept of bastion hosting in that they handle all incoming requests from the Internet to the corporate network, such as FTP or web requests. Bastion hosts are heavily fortified against attack. By having only a single host handling incoming requests, it is easier to maintain security and track attacks. Therefore, in the event of a break-in, only the firewall system has been compromised, not the entire network. In this way, none of the computers or hosts on the corporate network can be contacted directly for requests from the Internet, providing an effective level or layer of security.

Additionally, application-based firewall systems are set up as proxy servers to act on the behalf of someone inside an organization's private network. Rather than relying on a generic packet filtering tool to manage the flow of Internet services through the firewall, a special-purpose code called a proxy server is incorporated into the firewall system. For example, when someone inside the corporate network wants to access a server on the Internet, a request from the computer is sent to the proxy server, the proxy server contacts the server on the Internet, and the proxy server then sends the information from the Internet server to the computer inside the corporate network. By acting as a go-between, proxy servers can maintain security by examining a service's (e.g., FTP, Telnet) program code and modifying and securing it to eliminate known vulnerabilities. The proxy server can also log all traffic between the Internet and the network.

The application-level firewall implementation of proxy server functions is based on providing a separate proxy for each application service (e.g., FTP, Telnet, HTTP). This differs from circuit-level firewalls, which do not need a special proxy for each application-level service. In other words, one proxy server is used for all services.

Advantages of these types of firewalls are that they provide security for commonly used protocols and generally hide the internal network from outside untrusted networks. For example, a feature available on these types of firewall systems is the network address translation (NAT) capability. This capability takes private internal network addresses (unusable on the Internet) and maps them to a table of public IP addresses, assigned to the organization, which can be used across the Internet.

Disadvantages are poor performance and scalability as Internet usage grows. To offset this problem, the concept of load balancing is applicable in cases where a redundant fail-over firewall system may be used.

STATEFUL INSPECTION FIREWALLS

A stateful inspection firewall keeps track of the destination IP address of each packet that leaves the organization's internal network. Whenever the response to a packet is received, its record is referenced to ascertain and ensure that the incoming message is in response to the request that went out from the organization. This is done by mapping the source IP address of an incoming packet with the list of destination IP addresses that is maintained and updated. This approach prevents any attack initiated and originated by an outsider.

The advantages of this approach over application firewall systems is that stateful inspection firewalls control the flow of IP traffic by matching information contained in the headers of connection-oriented or connectionless IP packets at the transport layer, against a set of rules specified by the firewall administrator. This provides a greater degree of efficiency when compared to typical CPU-intensive, full-time application firewall systems' proxy servers, which may perform extensive processing on each data packet at the application level.

The disadvantages include that stateful inspection firewalls can be relatively complex to administer compared to the other two types of firewalls.

Examples of Firewall Implementations

Firewall implementations can take advantage of the functionality available in a variety of firewall designs to provide a robust layered approach in protecting an organization's information assets. Commonly used implementations available today include:

- **Screened-host firewall**—Utilizing a packet-filtering router and a bastion host, this approach implements basic network layer security (packet filtering) and application server security (proxy services). An intruder in this configuration has to penetrate two separate systems before the security of the private network can be compromised. This firewall system is configured with the bastion host connected to the private network with a packet filtering router between the Internet and the bastion host. Router filtering rules allow inbound traffic to access only the bastion host, which blocks access to internal systems. Because the inside hosts reside on the same network as the bastion host, the security policy of the organization determines whether inside systems are permitted direct access to the Internet or whether they are required to use the proxy services on the bastion host.
- **Dual-homed firewall**—This is a firewall system that has two or more network interfaces, each of which is connected to a different network. In a firewall configuration, a dual-homed firewall usually acts to block or filter some or all of the traffic trying to pass between the networks. A dual-homed firewall system is a more restrictive form of a screened-host firewall system, in which a dual-homed bastion host is configured with one interface established for information servers and another for private network host computers.
- **Demilitarized zone (DMZ) or screened-subnet firewall**—Utilizing two packet-filtering routers and a bastion host, this approach creates the most

secure firewall system because it supports network- and application-level security while defining a separate DMZ network. The DMZ functions as a small, isolated network for an organization's public servers, bastion host information servers and modem pools. Typically, DMZs are configured to limit access from the Internet and the organization's private network. Incoming traffic access is restricted into the DMZ network by the outside router and protects the organization against certain attacks by limiting the services available for use. Consequently, external systems can access only the bastion host (and its proxying service capabilities to internal systems) and possibly information servers in the DMZ. The inside router provides a second line of defense, managing DMZ access to the private network, while accepting only traffic originating from the bastion host. For outbound traffic, the inside router manages private network access to the DMZ network. It permits internal systems to access only the bastion host and information servers in the DMZ. The filtering rules on the outside router require the use of proxy services by accepting only outbound traffic on the bastion host. The key benefits of this system are that an intruder must penetrate three separate devices, private network addresses are not disclosed to the Internet, and internal systems do not have direct access to the Internet.

Firewall Issues

Issues related to implementing firewalls include:

- A false sense of security may exist where management feels that no further security checks and controls are needed on the internal network (i.e., the majority of incidents are caused by insiders, who are not controlled by firewalls).
- The circumvention of firewalls through the use of modems may connect users directly to ISPs. Management should provide assurance that the use of modems when a firewall exists is strictly controlled or prohibited altogether.
- Misconfigured firewalls may allow unknown and dangerous services to pass through freely.
- What constitutes a firewall may be misunderstood (e.g., companies claiming to have a firewall merely have a screening router).
- Monitoring activities may not occur on a regular basis (i.e., log settings not appropriately applied and reviewed).
- Firewall policies may not be maintained regularly.
- Most firewalls operate at the network layer; therefore, they do not stop any application-based or input-based attacks. Examples of such attacks include structured query language (SQL) injection and buffer-overflow attacks. Newer-generation firewalls are able to inspect traffic at the application layer and stop some of these attacks.

Firewall Platforms

Firewalls may be implemented using hardware or software platforms. When implemented in hardware, it will provide good performance with minimal system overhead. Although hardware-based firewall platforms are faster, they are not as flexible or scalable as software-based firewalls. Software-based firewalls are generally slower with significant systems overhead; however, they are flexible with additional services. They may include content and virus checking, before traffic is passed to users.

It is generally better to use appliances, rather than normal servers, for the firewall. Appliances are normally installed with hardened OSs. When server-based firewalls are used, OSs in servers are often vulnerable to attacks. When the attacks on OSs succeed, the firewall would be compromised. Appliance-type firewalls are, generally, significantly faster to set up and recover.

Intrusion Detection Systems

Another element to securing networks complementing firewall implementations is an IDS. An IDS works in conjunction with routers and firewalls by monitoring network usage anomalies. It protects a company's IS resources from external as well as internal misuse.

An IDS operates continuously on the system, running in the background and notifying administrators when it detects a perceived threat. Broad categories of IDSs include:

- **Network-based IDSs**—They identify attacks within the monitored network and issue a warning to the operator. If a network-based IDS is placed between the Internet and the firewall, it will detect all the attack attempts, whether or not they enter the firewall. If the IDS is placed between a firewall and the corporate network, it will detect those attacks that enter the firewall (it will detect intruders). The IDS is not a substitute for a firewall, but it complements the function of a firewall.
- **Host-based IDSs**—They are configured for a specific environment and will monitor various internal resources of the OS to warn of a possible attack. They can detect the modification of executable programs, detect the deletion of files and issue a warning when an attempt is made to use a privileged command.

Components of an IDS are:

- Sensors that are responsible for collecting data, such as network packets, log files, system call traces, etc.
- Analyzers that receive input from sensors and determine intrusive activity
- An administration console
- A user interface

Types of IDSs include:

- **Signature-based**—These IDS systems protect against detected intrusion patterns. Identified intrusive patterns are stored as signatures.
- **Statistical-based**—These systems need a comprehensive definition of the known and expected behavior of systems.
- **Neural networks**—An IDS with this feature monitors the general patterns of activity and traffic on the network and creates a database. This is similar to the statistical model but with added self-learning functionality.

Signature-based IDSs will not be able to detect all types of intrusions due to the limitations of the detection rules. Statistical-based systems may report many events outside of the defined normal activity but which are normal activities on the network. A combination of signature- and statistical-based models provides better protection.

FEATURES

The features available in an IDS include:

- Intrusion detection
- Gathering evidence on intrusive activity
- Automated response (i.e., termination of connection, alarm messaging)
- Security policy
- Interface with system tools
- Security policy management

LIMITATIONS
An IDS cannot help with the following weaknesses:
- Weaknesses in the policy definition
- Application-level vulnerabilities
- Back doors into applications
- Weaknesses in identification and authentication schemes

In contrast to IDSs, which rely on signature files to identify an attack as (or after) it happens, an intrusion prevention system (IPS) predicts an attack before it can take effect. It does this by monitoring key areas of a computer system and looks for "bad behavior" such as worms, Trojans, spyware, malware and hackers. It complements firewall, antivirus and antispyware tools to provide complete protection from emerging threats. It is able to block new (zero-day) threats that bypass traditional security measures because it is not reliant on identifying and distributing threat signatures or patches.

POLICY
An IDS policy should establish the action to be taken by security personnel in the event that an intruder is detected.

Actions may include:
- **Terminate the access**—If there is a significant risk to the organization's data or systems, immediate termination is the usual procedure.
- **Trace the access**—If the risk to the data is low, the activity is not immediately threatening, or analysis of the entry point and attack method is desirable, the IDS can be used to trace the origin of the intrusion. This can be used to determine and correct any system weaknesses and to collect evidence of the attack which may be used in a subsequent court action.

In either case, the action required should be determined by management in advance and incorporated in a policy. This will save time when an intrusion is detected, which may impact the possible data loss.

Intrusion Prevention Systems
Intrusion prevention systems (IPSs) are closely related to IDSs and are designed to not only detect attacks, but also to prevent the intended victim hosts from being affected by the attacks. Whereas an IDS alerts or warns of an attack, requiring security personnel to take action, an IPS will make an attempt to stop the attack. For example, an IPS can disconnect an originating network or user session by blocking access to the target from the originating user account and/or IP address. Some IPSs can also reconfigure other security controls, such as a firewall or router, to block an attack. The intrusion prevention approach can be effective in limiting damage or disruption to systems that are attacked. However, as with an IDS, the IPS must be properly configured and tuned to be effective. Threshold settings that are too high or low will lead to limited effectiveness of the IPS. Some concerns have been raised that the IPS itself may constitute a threat because a clever attacker could send commands to a large number of hosts protected by an IPS in order to cause them to become dysfunctional. This could be catastrophic in environments where continuity of service is critical.

Honeypots and Honeynets
A honeypot is a software application that pretends to be a vulnerable server on the Internet and is not set up to actively protect against break-ins. It acts as a decoy system that lures hackers. The more a honeypot is targeted by an intruder, the more valuable it becomes. Although honeypots are technically related to IDSs and firewalls, they have no real production value as an active sentinel of networks.

There are two basic types of honeypots:
- **High-interaction**—Give hackers a real environment to attack
- **Low-interaction**—Emulate production environments and provide more limited information

A honeynet is a set of multiple, linked honeypots that simulate a larger network installation. Hackers infiltrate the honeynet, which allows investigators to observe their actions using a combination of surveillance technologies.

An IDS triggers a virtual alarm whenever an attacker breaches security of any networked computers. A stealthy keystroke logger watches everything the intruder types. A separate firewall cuts off the machines from the Internet anytime an intruder tries to attack another system from the honeynet.

All traffic on honeypots or honeynets are assumed to be suspicious because the systems are not meant for internal use and the information collected about these attacks are used proactively to update vulnerabilities on a company's live network.

If a honeypot is designed to be accessible from the Internet, there is a risk that external monitoring services that create lists of untrusted sites may report the organization's system as vulnerable, without knowing that the vulnerabilities belong to the honeypot and not to the system itself. Such independent reviews made public can affect the organization's reputation. Therefore, prior to implementing a honeypot in the network, careful judgment should be exercised.

5.4.5 ENCRYPTION

Encryption is the process of converting a plaintext message into a secure-coded form of text, called ciphertext, which cannot be understood without converting it back via decryption (the reverse process) to plaintext. This is done via a mathematical function and a special encryption/decryption password called the key.

Encryption generally is used to:
- Protect data in transit over networks from unauthorized interception and manipulation
- Protect information stored on computers from unauthorized viewing and manipulation
- Deter and detect accidental or intentional alterations of data
- Verify authenticity of a transaction or document

In many countries, encryption is subject to governmental laws and regulations.

Encryption is limited in that it cannot prevent the loss or modification of data. The protection of the keys is of paramount concern when using encryption systems. Therefore, even if encryption is regarded as an essential form of access control that should be incorporated into an organization's overall security landscape, it requires a thorough understanding of how schemes work as misuse or misconfiguration may significantly undermine the protection that an organization believes is in place.

Key Elements of Encryption Systems
Key elements of encryption systems include:
- **Encryption algorithm**—A mathematically based function that encrypts/decrypts data
- **Encryption keys**—A piece of information that is used by the encryption algorithm to make the encryption or decryption process unique. Similar to passwords, a user needs to provide the correct key to access or decrypt a message. The wrong key will decipher the message into an unreadable form.
- **Key Length**—A predetermined length for the key. The longer the key, the more difficult it is to compromise in a brute force attack.

Encryption schemes are susceptible to brute force attacks in which an attacker repeatedly tries to decrypt a piece of ciphertext using all the possible encryption keys until the correct one is found (i.e., brute forcing stops when the ciphertext does not decrypt to a non-sense message). As the amount of time required to search for the correct key depends exponentially on its length, it is fundamental to choose the key adequately in order to ensure the overall security of encryption scheme.

Attacks can also be mounted against the robustness of the underlying mathematical algorithms in order to speed-up the brute forcing process. Cryptanalysis is the science of finding such weaknesses. For example, an algorithm prone to a "known-plaintext attack" allows an attacker discard a large portion of the possible decryption keys if samples of ciphertexts and corresponding plaintexts are available. A variation of this attack consists of guessing parts of the plaintext leveraging on statistical properties of the encrypted data (e.g., spotting vowels or finding the word "the" in an English text).

The randomness of key generation is also a significant factor in the ability to compromise an encryption scheme. Common words or phrases significantly lessen the key space combinations required to search for the key, diminishing the strength of the encryption algorithm. Therefore, a 128-bit encryption algorithm's capabilities are diminished when encrypting keys are based on passwords, and the passwords lack randomness. This means that it is important that effective password syntax rules are applied, and easily guessed passwords are prohibited.

There are two types of encryption schemes: symmetric and asymmetric. Symmetric key systems use a unique key (usually referred to as the "secret key") for both encryption and decryption. The key is known as bidirectional because it encrypts and decrypts and it must be shared "out of band" (i.e., via a secure, alternative method to the encrypted message).

In asymmetric key systems the decryption key is different than the one used for encryption. The keys are unidirectional, they encrypt or decrypt, but complementary. In asymmetric key systems, the two parties (the sender and the recipient) are not expected to trust each other to keep the secret key. In fact, in asymmetric systems the encryption key is publicly disclosed while the decryption key is kept private (asymmetric systems are also known as public-key schemes).

Together with encryption algorithms, another important component of cryptographic protection schemes are hash functions. These functions transform a text of arbitrary length into one of fixed width called the "digest" or the "hash" of the input text (a basic example of a hash function is one that just truncates a text string after a fixed number of characters). To be used in cryptographic protection schemes, a hash function must be "one-way" (i.e., making it hard to find a piece of text that generates a given hash). Such functions can be used to augment encryption schemes with integrity and authenticity properties. Hashing algorithms are an accurate integrity check tool. The hash detects changes of even a single bit in a message. A hash algorithm will calculate a hash value from the entire input message. The output digest itself is a fixed length, so even though the input message can be of variable length, the output is always the same length. The length depends on the hash algorithm used. For example, MD5 generates a digest length of 128 bits; SHA-1, a digest of 160 bits; and SHA-512, a digest of 512 bits.

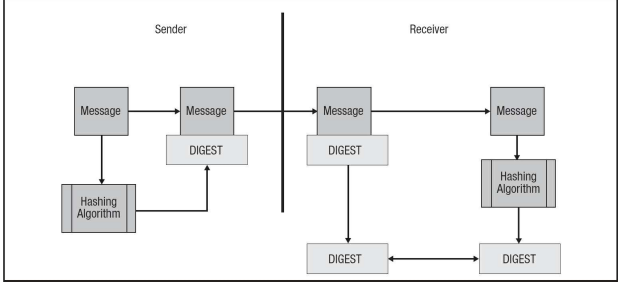
The most common message digest algorithms have been MD5, now moved to historic (datatracker.ietf.org/doc/rfc6331/) and SHA-1for which there are also security considerations (datatracker.ietf.org/doc/rfc6194/). For these reasons the industry is transitioning from SHA-1 to SHA-2. There are six hash functions available with SHA-2 with varying message digest lengths. SHA-3 has also been announced by the National Institute for Standards and Technology (NIST) in the event a successful attack is developed against SHA-2.

> **Note:** The IS auditor should be familiar with how a digital signature functions to protect data. The specific types of message digest algorithms are not tested on the CISA exam.

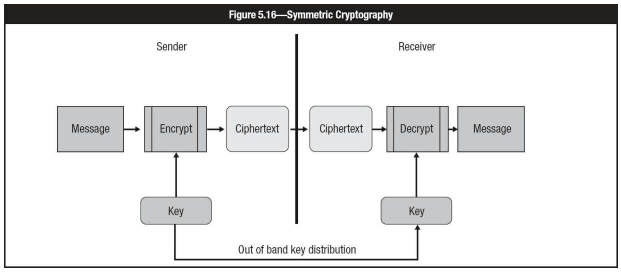
When a sender wants to send a message and ensure that it has not been altered, they can compute the digest of the message and send it along with the message to the receiver. When the receiver receives the message and its digest, he/she independently computes the digest of the received message and ensures that the digest computed is the same as the digest sent with the message (**figure 5.15**).

Symmetric Key Cryptographic Systems
Symmetric key cryptographic systems (**figure 5.16**) are based on a symmetric encryption algorithm, which uses a secret key to encrypt the plaintext to the ciphertext and the same key to decrypt the ciphertext to the corresponding plaintext. In this case, the key is said to be symmetric because the encryption key is the same as the decryption key.

Figure 5.15— Verifying Message Integrity Using a Hash Function



Source: ISACA, *CRISC Review Manual 6th Edition*, USA, 2015, figure 3.8



Source: ISACA, *CRISC Review Manual 6th Edition*, USA, 2015, figure 3.6

The most common symmetric key cryptographic system used to be the Data Encryption Standard (DES). DES is based on a public algorithm approved by NIST and employs keys of 56 bits (plus 8 bits used for parity checking). The bits in the plaintext are processed one 64-bit block at a time and, as such, DES belongs to the category of block-ciphers (as opposed to stream-ciphers, which encode one bit at a time).

DES has been withdrawn by NIST because it is no longer considered a strong cryptographic solution because its entire key space can be brute forced by a moderately large computer system within a relatively short period of time. Extensions of DES (Triple DES or 3DES) were proposed to extend the DES standard while retaining backward compatibility (it applies the DES cipher algorithm three times to each data block). In 2001, NIST replaced DES with the Advanced Encryption Standard (AES), a public algorithm that supports keys from 128 bits to 256 bits in size. Another commonly used symmetric key algorithm is RC4, a stream-cipher often used in SSL/TLS protocol sessions.

There are two main advantages of symmetric key systems such as 3DES or AES over asymmetric ones. The first is that keys are much shorter and can be easily remembered. The second is that symmetric key cryptosystems are generally less complicated and, therefore, use less processing power than asymmetric schemes. This makes symmetric key cryptosystems ideally suited for bulk data encryption. The major disadvantage of this approach is key distribution, particularly in e-commerce environments where customers are unknown, untrusted entities. Also, a symmetric key cannot be used to sign electronic documents or messages due to the fact that the mechanism is based on a shared secret by at least two parties.

Public (Asymmetric) Key Cryptographic Systems

In public key cryptography (**figure 5.17**), two keys work together as a pair (they are inversely related to each other, based on mathematical integer factorization). One of the keys is kept private while the other one is publicly disclosed. Encryption works by feeding the public key to the underlying algorithm while the resulting ciphertext can be decoded using the private key. This scheme avoids requirement of the owner of the key pair to share a secret piece of information (the private key) with the other party of the communication. It is important to note that one key pair can be used in one-direction only (from the sender to the receiver). To implement a bidirectional communication between two parties, two key-pairs are required (one for each direction).

Public key systems were developed primarily to solve the problem of key distribution. In the first place only 2*N key-pairs are employed in a scenario in which communication happens between N parties: in the same scenario, a symmetric scheme would require roughly N^2 keys to be transmitted, one key for each pair of the involved parties. In addition, the exchanged keys are public, thus there is no confidentiality requirement to be fulfilled by the key distribution protocol.

The first practical implementation of a public key system was developed by Ron Rivest, Adi Shamir and Leonard Adleman (the RSA algorithm), which is a widespread asymmetric encryption scheme. The main drawback of this algorithm lies in the length of the keys (varying between 1024 and 4096 bits) and the complexity of the calculations involved for encoding and decoding. To address these issues, other encryption algorithms were developed. Promising alternatives like elliptic curve cryptography (ECC) are emerging because they have a much higher speed at encrypting/decrypting with significantly shorter keys (between 256 and 512 bits).

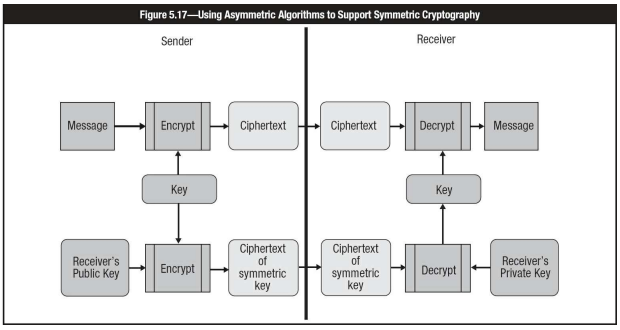
Quantum Cryptography

Quantum cryptography refers to the possibility of using properties of quantum computing (computer technology based on quantum theory) for cryptographic purposes, quantum key distribution (QKD) being the most important application. QKD schemes allow distribution of a shared encryption key between two parties who can detect when another unauthorized party is eavesdropping on the key exchange channel. Indeed, when this happens, the channel is inevitably disturbed and the exchanged key is tagged as compromised.

Quantum computing is also known to easily break the security of schemes like RSA. To overcome this drawback, post-quantum encryption algorithms have been developed which are resistant to a quantum attack.

Digital Signatures

An important property of public key systems is that the underlying algorithm works even if the private key is used for encryption and the public key for decryption. Even if this sounds counterintuitive, this way of using a public key system realizes a digital signature scheme able to authenticate the origin of an encoded message. Because the private key is known only by the owner of the key-pair, one can be sure that if a ciphertext is correctly decrypted using a public key, the owner of that public key cannot deny to have performed the encryption process. This important and peculiar property of public key cryptosystems is called non-repudiation.



Source: ISACA, *CRISC Review Manual 6th Edition*, USA, 2015, figure 3.7

In most practical implementations of digital signature schemes (**figure 5.18**), the public key algorithm is never applied to the whole document as it would take a lot of processing power to calculate the signed data. Instead, a digest (or "pre hash") is first derived from the document to be signed; then the public key algorithm is applied to the digest in order to produce an encoded piece of data (the signature) that is sent alongside the document.

In order to authenticate the sender as the originator of the document, the same hashing function is applied by the recipient upon receiving and the resulting digest (or "post-hash") is compared with the decrypted pre-hash. In case of a match, the receiver can conclude that the document was actually signed by the owner of the public key.

Therefore, digital signature schemes ensure:
- **Data integrity**— Any change to the plaintext message would result in the recipient failing to compute the same document hash.
- **Authentication**—The recipient can ensure that the document has been sent by the claimed sender because only the claimed sender has the private key.
- **Nonrepudiation**— The claimed sender cannot later deny generating the document.

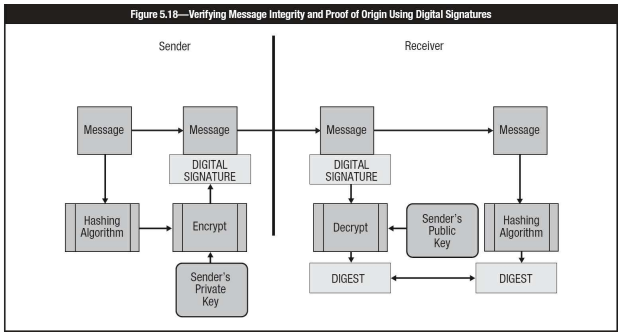
Notice that there is no guarantee that the owner of the public key actually sent the document. A malicious attacker could intercept the signed document and send it again to the recipient. To prevent this kind of attack (known as "replay attack"), a signed timestamping or a counter may be attached to the document.

Public Key Infrastructure
Public key encryption algorithms are a big step toward strengthening the trust of secure communications because private keys must not be shared by any of the parties involved in the system and no confidentiality requirements are imposed when distributing public keys.

However, public key systems are still vulnerable to man-in-the-middle (MITM) attacks in which the public keys are tampered with by an attacker (the man in the middle) controlling the communication channel. If this attacker replaces a genuine public key with his own key, any party sending a message to the owner of the tampered public key would instead be using the attacker's public key. This attacker is now able to intercept, read and modify any such message by decrypting and re-encrypting it using the genuine public key. The problem lies in the fact that the tampering of the public key cannot be detected by either the sender or the recipient. In other words, there is no guarantee of a binding between the public key and the identity of the owner.

To solve this problem, a trusted third party is introduced into the scheme from which any signed document is considered automatically authentic by the sender and the recipient. In the first place, this trusted party identifies the holder of a public key (the subject) and then signs this public key while appending details of the subject's identity. The resulting document is known as the public (or digital) certificate of the subject. The trusted third party is called a certification authority (CA). When a CA is introduced in a signature scheme it is known as public key infrastructure (PKI).

As well as issuing certificates, the CA maintains a list of compromised certificates (i.e., those whose private key has been leaked or lost) called the certificate revocation list (CRL). In some cases, certificates may also be marked as revoked in the CRL when the owner of the certificate voluntarily declares not to use the corresponding key pair any longer. This allows a party to reject a signed document when the signature was generated after the private key has been compromised or revoked.



Source: ISACA, *CRISC Review Manual 2015*, USA, 2014

Certificates usually contain a certificate practice statement (CPS). This is a statement about the way a CA issues certificates. It may contain:
- The type of certificates issued
- Policies, procedures and processes for issuing, renewing and recovering certificates
- Cryptographic algorithms used
- The key length used for the certificate

- The lifetime of the certificate issued by the CA
- Policies for revoking certificates
- Policies for CRLs
- Policies for renewing certificates

Registration authorities (RA) are delegated some administrative functions for a specific community by the CA. For example, an international corporation may have a PKI setting in which national branches act as RAs for the employees in that nation.

The administrative functions that a particular RA implements will vary based on the needs of the CA but must support the principle of establishing or verifying the identity of the subscriber. These functions may include the following:
- Verifying information supplied by the subject (personal authentication functions)
- Verifying the right of the subject to requested certificate attributes
- Verifying that the subject actually possesses the private key being registered and that it matches the public key requested for a certificate (generally referred to as proof of possession [POP]).
- Reporting key compromise or termination cases where revocation is required
- Assigning names for identification purposes
- Generating shared secrets for use during the initialization and certificate pick-up phases of registration
- Initiating the registration process with the CA on behalf of the subject end entity
- Initiating the key recovery processing
- Distributing the physical tokens (such as smart cards) containing the private keys

Applications of Cryptographic Systems
Asymmetric and symmetric systems can be combined together to leverage on each system's peculiarities. A common scheme is to encrypt data using a symmetric algorithm with a secret key, which is randomly generated. The secret key is then encrypted using an asymmetric encryption algorithm to allow the secure distribution among those parties who need access to the encrypted data. Secure communication can thus enjoy both the speed of symmetric systems and the ease of key-distribution of asymmetric systems. In addition, because creating the secret key is an effortless operation, it can be employed just for a limited amount of data after which a new secret key can be chosen. This limits the possibilities of a malicious third-party to decrypt the whole set of data because he would be required to attack multiple secret keys. This combined scheme is used in protocols like SSL/TLS to protect web traffic and S/MIME for email encryption. In the latter case, the resulting document—the combination of the encrypted message and the encrypted secret key—is called a digital envelope.

A more comprehensive list of applications of such a method follows.

TRANSPORT LAYER SECURITY (TLS)
TLS is a cryptographic protocol that provides secure communications on the Internet. TLS is a session- or connection-layered protocol widely used for communication between browsers and web servers. Besides communication privacy, it also provides endpoint authentication. The protocols allow client-server applications to communicate in a way designed to prevent eavesdropping, tampering and message forgery.

TLS involves a number of basic phases:
- Peer negotiation for algorithm support
- Public-key, encryption-based key exchange and certificate-based authentication
- Symmetric cipher-based traffic encryption

During the first phase, the client and server negotiate which cryptographic algorithms will be used. Current implementations support the following choices:
- For public-key cryptography: RSA, Diffie-Hellman, DSA or Fortezza
- For symmetric ciphers: RC4, IDEA, Triple DES or AES
- For one-way hash functions: SHA-1 or SHA-2 (SHA-256)

TLS runs on layers above the TCP transport protocol and provides security to application protocols, even if it is most commonly used with HTTP to form Secure Hypertext Transmission Protocol (HTTPS). HTTPS serves to secure World Wide Web pages for applications. More, in electronic commerce, authentication may be used both in business-to-business (B-to-B) activities (for which both the client and the server are authenticated) and business-to-consumer (B-to-C) interaction (in which only the server is authenticated).

Besides TLS, Secure Socket Layer (SSL) protocol is also widely used in real-world applications, even though its use is now deprecated as a significant vulnerability was discovered in 2014. TLS and SSL are not interchangeable.

IP SECURITY (IPSEC)
IPSec is used for securing the communications at IP-level among two or more hosts, two or more subnets, or hosts and subnets.

This IP network layer packet security protocol establishes VPNs via transport and tunnel mode encryption methods. For the transport method, the data portion of each packet referred to as the encapsulation security payload (ESP) is encrypted, achieving confidentiality over the process. In the tunnel mode, the ESP payload and its header are encrypted. To achieve nonrepudiation, an additional authentication header (AH) is applied.

In establishing IPSec sessions in either mode, security associations (SAs) are established. SAs define which security parameters should be applied between the communicating parties as encryption algorithms, keys, initialization vectors, life span of keys, etc. Within either the ESP or AH header, respectively, an SA is established when a 32-bit security parameter index (SPI) field is defined within the sending host. The SPI is a unique identifier that enables the sending host to reference the security parameters to apply, as specified, on the receiving host.

IPSec can be made more secure by using asymmetric encryption through the use of Internet Security Association and Key Management Protocol/Oakley (ISAKMP/Oakley), which allows the key management, use of public keys, negotiation, establishment, modification and deletion of SAs and attributes. For authentication, the sender uses digital certificates. The connection is made secure by supporting the generation, authentication and distribution of the SAs and those of the cryptographic keys.

SECURE SHELL (SSH)

SSH is a client-server program that opens a secure, encrypted command-line shell session from the Internet for remote logon. Similar to a VPN, SSH uses strong cryptography to protect data, including passwords, binary files and administrative commands, transmitted between systems on a network. SSH is typically implemented between two parties by validating each other's credentials via digital certificates. SSH is useful in replacing Telnet and is implemented at the application layer, as opposed to operating at the network layer (IPSec implementation).

SECURE MULTIPURPOSE INTERNET MAIL EXTENSIONS (S/MIME)
S/MIME is a standard secure email protocol that authenticates the identity of the sender and receiver, verifies message integrity, and ensures the privacy of a message's contents, including attachments.

5.4.6 MALWARE

The term malware is generally applied to a variety of malicious computer programs that send out requests to the OS of the host system under attack to append the malware to other programs. In this way, malware are self-propagating to other programs. They can be relatively benign (e.g., web application defacement) or malicious (e.g., deleting files, corrupting programs or causing a DoS). Generally, malware attack four parts of the computer:
- Executable program files
- The file-directory system, which tracks the location of all the computer's files
- Boot and system areas, which are needed to start the computer
- Data files

Another variant of malware frequently encountered is a worm, which, unlike a virus, does not physically attach itself to another program. To propagate itself to the host systems, a worm typically exploits security weaknesses in OSs' configurations. These problems are particularly severe in today's highly decentralized client-server environments.

Currently, viruses or worms are transmitted easily from the Internet by downloading files to computers' web browsers. Malware are also transmitted as attachments to email, so that when the attachment opens, the system becomes infected if it is not using scanning software to review unopened attachments. Other methods of infection occur from files received through online services, social media, LANs and even shrink-wrapped software that the user may buy from a retail store.

Virus and Worm Controls
To effectively reduce the risk of computer viruses and worms infiltrating an organization, a comprehensive and dynamic anti-malware program needs to be established. There are two major ways to prevent and detect malware that infect computers and network systems. The first is by having sound policies and procedures in place (preventive controls) and the second is by technical means (detective controls), including anti-malware software. Neither is effective without the other.

Management Procedural Controls
Some of the policy and procedure controls that should be in place include the following:
- Build any system from original, clean master copies. Boot only from original media whose write protection has always been in place, if applicable.
- Allow no media (e.g., hard/flash drives) to be used until they have been scanned on a stand-alone machine that is used for no other purpose and is not connected to the network.
- Update malware software scanning definitions/signatures frequently.
- Protect removable media against theft and hazards.
- Have vendors run demonstrations on their machines.
- Enforce a rule of not using shareware without first scanning it thoroughly for malware.
- Scan before any new software is installed because commercial software occasionally includes a Trojan horse (viruses or worms).
- Insist that field technicians scan their disks on a test machine before they use any of their disks on the system.
- Ensure the network administrator uses workstation and server anti-malware software.
- Ensure all servers are equipped with an activated current release of the malware-detection software.
- Consider encrypting files and then decrypting them before execution.
- Ensure bridge, router and gateway updates are authentic.
- Because backups are a vital element of an anti-malware strategy, ensure a sound and effective backup plan is in place. This plan should account for scanning selected backup files for malware infection once malware has been detected.
- Educate users so they will heed these policies and procedures. For example, many malware today are propagated in the form of email attachments where the attachment, such as an executable Visual Basic script, infects the user's system upon opening the attachment. The hacker relies upon social engineering tactics in getting the user to open the attachment.
- Review anti-malware policies and procedures at least once a year.
- Prepare a malware eradication procedure and identify a contact person.
- Develop, rehearse and maintain clear incident management procedures in the event that anti-malware software reports an infection.

Technical Controls
Technical methods of preventing malware can be implemented through hardware and software means. The following are hardware tactics that can reduce the risk of infection:
- Use boot malware protection (i.e., built-in, firmware-based malware protection).
- Use remote booting (e.g., diskless workstations).
- Use a hardware-based password.
- Protect removable media against theft and hazards.
- Ensure that insecure protocols are blocked by the firewall from external segments and the Internet.

However, anti-malware software is, by far, the most common anti-malware tool and is considered the most effective means of protecting networks and host-based computer systems against malware. Anti-malware software is both a preventive and a detective control. Unless updated periodically, anti-malware software will not be an effective tool against malware.

Anti-malware software contains a number of components that address the detection of malware via scanning technologies from different angles. There are different types of anti-malware software.

Scanners look for sequences of bits called signatures that are typical of malware programs. The two primary types are:
- Malware masks or signatures—Anti-malware scanners check files, sectors and system memory for known and new (unknown to scanner) malware, on the basis of malware masks or signatures. Malware masks or signatures are specific code strings that are recognized as belonging to malware. For polymorphic viruses, the scanner sometimes has algorithms that check for all possible combinations of a signature that could exist in an infected file.
- Heuristic scanners—Analyzes the instructions in the code being scanned and decides on the basis of statistical probability whether it could contain malicious code. Heuristic scanning results could indicate that malware may be present (i.e., possibly infected). Heuristic scanners tend to generate a high level of false-positive errors (i.e., they indicate that malware may be present when, in fact, no malware is present).

Scanners examine memory, disk-boot sectors, executables, data files and command files for bit patterns that match a known malware. Scanners, therefore, need to be updated periodically to remain effective.

Active monitors interpret DOS and read-only memory (ROM) BIOS calls, looking for malware-like actions. Active monitors can be problematic because they cannot distinguish between a user request and a program or malware request. As a result, users are asked to confirm actions, including formatting a disk or deleting a file or set of files.

Integrity CRC checkers compute a binary number on a known malware-free program that is then stored in a database file. The number is called a cyclical redundancy check (CRC). On subsequent scans, when that program is called to execute, it checks for changes to the files as compared to the database and reports possible infection if changes have occurred. A match means no infection; a mismatch means a change in the program has occurred. A change in the program could mean malware within it. These scanners are effective in detecting infection; however, they can do so only after infection has occurred (i.e., it is often too late to save files). Also, CRC checkers can only detect subsequent changes to files, because they assume files are malware free in the first place. Therefore, they are ineffective against new files that are malware-infected and that are not recorded in the database. Integrity checkers take advantage of the fact that executable programs and boot sectors do not change often, if at all.

Behavior blockers focus on detecting potentially abnormal behavior, such as writing to the boot sector or the master boot record or making changes to executable files. Blockers can potentially detect malware at an early stage. Most hardware-based anti-malware mechanisms are based on this concept.

Immunizers defend against malware by appending sections of themselves to files—somewhat in the same way that file malware append themselves. Immunizers continuously check the file for changes and report changes as possible malware behavior. Other types of immunizers are focused to a specific virus and work by giving the malware the impression that the malware has already infected the computer. This method is not always practical because it is not possible to immunize files against all known malware.

Once malware has been detected by anti-malware software, an eradication program can be used to wipe the malware from the hard disk. Sometimes eradication programs can kill the malware without having to delete the infected program or data file, while other times those infected files must be deleted. Still, other programs, sometimes called inoculators, do not allow a program to be run if it contains malware.

Anti-malware Software Implementation Strategies
Organizations have to develop malware implementation strategies to effectively control and prevent the spread of malware throughout their IS infrastructure. An important means of controlling the spread of malware is to detect the malware at its point of entry—before it has the opportunity to cause damage. This includes everything from networks, server platforms and end-user workstations.

The user server or workstation level could include screening of software and data as they enter the machine, where anti-malware programs can be set to perform:
- Scheduled malware scans (e.g., daily, weekly, etc.)
- Manual/on-demand scans, where the malware scan is requested by the user
- Continuous/on-the-fly scanning, where files are scanned as they are processed

At the corporate network level, in cases of interconnected networks, malware scanning software is used as an integral part of firewall technologies, referred to as malware walls. Malware walls scan incoming traffic with the intent of detecting and removing malware before they enter the protected network. Malware walls normally work at the following levels:
- SMTP protection, to scan inbound and outbound SMTP traffic for malware in coordination with the mail server
- HTTP protection, to prevent malware-infected files from being downloaded and to offer protection against malicious Java and ActiveX programs
- FTP protection, to prevent infected files from being downloaded

Malware walls most often are updated automatically with new malware signatures by their vendors on a scheduled basis or on an as-needed basis when dangerous, new malware emerge. Malware walls also provide facilities to log malware incidents and deal with the incident in accordance with preset rules. The presence of malware walls does not preclude the necessity for malware-detection software to be installed on computers within a network because the malware wall only addresses one channel through which malware enter the network. Malware-detection software should be loaded on all computers within the network. Malware signature files should be kept updated. The facility of automatic “live update” has become fairly popular and allows organizations to update the malware scanner signature files as soon as updates are available.

For malware scanners to be acceptable and viable, they should have the following features:
- Reliability and quality in the detection of malware
- Memory resident, which is a continuous checking facility
- Efficiency, such as a reasonable working speed and usage of resources

5.4.7 VOICE-OVER IP

IP telephony, also known as Internet telephony, is the technology that makes it possible to have a voice conversation over the Internet or over any dedicated IP network instead of dedicated voice transmission lines. The protocols used to carry the signal over the IP network are commonly referred to as Voice-over IP (VoIP). VoIP is a technology where voice traffic is carried on top of existing data infrastructure. Sounds are digitized into IP packets and transferred through the network layer before being decoded back into the original voice. VoIP has significantly reduced long-distance costs in a number of large organizations.

VoIP allows the elimination of circuit switching and the associated waste of bandwidth. Instead, packet switching is used, where IP packets with voice data

are sent over the network only when data needs to be sent.

It has advantages over traditional telephony:
- Unlike traditional telephony, VoIP innovation progresses at market rates rather than at the rates of the multilateral committee process of the International Telecommunications Union (ITU)
- Lower costs per call or even free calls, especially for long-distance calls
- Lower infrastructure costs. Once IP infrastructure is installed, no or little additional telephony infrastructure is needed.

VoIP introduces security risk and opportunities. VoIP has a different architecture than traditional circuit-based telephony, and these differences result in significant security issues.

VoIP systems take a wide variety of forms, including traditional telephone handsets, conferencing units and mobile units. In addition to end-user equipment, VoIP systems include a variety of other components, including call processors/call managers, gateways, routers, firewalls and protocols. Most of these components have counterparts used in data networks, but the performance demands of VoIP mean that ordinary network software and hardware must be supplemented with special VoIP components.

When designing a VoIP system, the backup has to be considered. While telecom companies usually operate under the requirement to have 99.9999 percent uptime, data traffic normally has less reliability. For this reason, the backup has to be designed to ensure that communication will not be interrupted should undesirable events occur on the data backbone. Bandwidth capacity should be baselined to determine the current levels of data traffic and adjust the necessary additional bandwidth for voice traffic. Quality of service will need to be defined so that voice traffic will be given priority over data traffic. Other considerations are laws and regulations. Certain countries may ban the use of VoIP.

VoIP Security Issues
With the introduction of VoIP, the need for security is more important because it is needed to protect two assets—the data and the voice.

Protecting the security of conversations in VoIP is vital now. In a conventional office telephone system, security is a more valid assumption. Intercepting conversations requires physical access to telephone lines or compromise of the office private branch exchange (PBX). Only particularly security-sensitive organizations bother to encrypt voice traffic over traditional telephone lines. It cannot be said for Internet-based connections. In VoIP, packets are sent over the network from a user's computer or VoIP phone to similar equipment on the other end. Packets may pass through several intermediate systems that are not under the control of the user's ISP. The current Internet architecture does not provide the same physical wire security as the phone lines. The key to securing VoIP is to use the security mechanisms such as those deployed in data networks (e.g., firewalls, encryption) to emulate the security level currently used by public switched telephone network (PSTN) network users.

The main concern with VoIP solutions is that while, in the case of traditional telephones, if the data system is disrupted, then different sites of the organization could still be reached via telephone. With VoIP, a computer system disruption also terminates the telephone because both are supported by the same devices. In this case, only mobile phones will function. Thus, a backup communications facility should be planned for if the availability of communications is vital to the organization. This would be the case with branches of financial institutions.

Another issue might arise with the fact that IP telephones and their supporting equipment require the same care and maintenance as computer systems do.

Thus, OS patches and virus signature updates must be promptly applied to prevent a potential system outage. To enhance the protection of the telephone system and data traffic, the VoIP infrastructure should be segregated using virtual local area networks (VLANs). Any connections between these two infrastructures should be protected using firewalls that can interpret VoIP protocols.

In many cases, session border controllers (SBCs) are utilized to provide security features for VolP traffic similar to that provided by firewalls. SBCs can be configured to filter specific VolP protocols, monitor for DoS attacks, and provide network address and protocol translation features.

5.4.8 PRIVATE BRANCH EXCHANGE

A PBX is a sophisticated computer-based switch that can be thought of as essentially a small, in-house phone company for the organization that operates it. Protection of the PBX is, thus, a high priority. Failure to secure a PBX can result in exposing the organization to toll fraud, theft of proprietary or confidential information, loss of revenue, or legal entanglements.

PBXs have been a part of organizations' communication infrastructures since the early 1920s, originally using analog technology. PBXs of today use digital technology; digital signals are converted to analog for outside calls on the local loop using Plain Old Telephone Service (POTS), which refers to the standard telephone service that most homes use.

Digital PBXs are widespread throughout industry and public organizations, having replaced their analog predecessors. The advent of software-based PBXs has provided a wealth of communications capabilities within these switches. Today, even the most basic PBX systems have a wide range of capabilities that were previously available only in large-scale switches. These new features have opened up many new opportunities for an intruder to attempt to exploit the PBX, particularly by usage of these features for a purpose that was never intended.

Attributes of today's PBXs include:
- More than two telephone trunk (multiple phone) lines that terminate at the PBX
- The use of digital phones that permit integrated voice/data workstations
- Scalable computer-based PBX systems with memory that manages the switching of the calls within the PBX
- Distributed architecture with multiple switches in a hierarchical or meshed configuration with distributed intelligence providing enhanced reliability
- Nonblocking configurations where all attached devices can be engaged in calls simultaneously
- The network of lines within the PBX
- An operator console or switchboard for a human operator

One of the principal purposes of a PBX is to save the cost of requiring a line for each user to the telephone company's central office. Also, it is easier to call someone within a PBX because only three or four digits need to be dialed.

PBX Risk

PBX environments involve many security risk, presented by people both internal and external to the organization. If a PBX is not correctly configured, back doors can be easily established for unauthorized purposes. The threats to PBX telephone systems are many, depending on the goals of these attackers, and include:

- **Theft of service**—Toll fraud, probably the most common of motives for attackers
- **Disclosure of information**—Data disclosed without authorization, either by deliberate action or by accident. Examples include eavesdropping on conversations and unauthorized access to routing and address data.
- **Data modification**—Data altered in some meaningful way by reordering, deleting or modifying it. For example, an intruder may change billing information or modify system tables to gain additional services.
- **Unauthorized access**—Actions that permit an unauthorized user to gain access to system resources or privileges
- **Denial of service**—Actions that prevent the system from functioning in accordance with its intended purpose. A piece of equipment or entity may be rendered inoperable or forced to operate in a degraded state; operations that depend on timeliness may be delayed.
- **Traffic analysis**—A form of passive attack in which an intruder observes information about calls (although not necessarily the contents of the messages) and makes inferences (e.g., from the source and destination numbers or frequency and length of the messages). For example, an intruder observes a high volume of calls between a company's legal department and patent office and concludes that a patent is being filed.

PBXs are sophisticated computer systems, and many of the threats and vulnerabilities associated with OSs are shared by PBXs. But there are two important ways in which PBX security is different from conventional OS security:

- **External access/control**—As with larger telephone switches, PBXs typically require remote maintenance by the vendor. Instead of relying on local administrators to make OS updates and patches, organizations normally have updates installed remotely by the switch manufacturer. This, of course, requires remote maintenance ports and access to the switch by a potentially large pool of outside parties.
- **Feature richness**—The wide variety of features available on PBXs, particularly administrative features and conference functions, provide the possibility of unexpected attacks. A feature may be used by an attacker in a manner that was not intended by its designers. Features may also interact in unpredictable ways, leading to system compromise, even if each component of the system conforms to its security requirements and the system is operated and administered correctly.

Some additional control weaknesses include:

- Uncontrolled definition of direct inward dial (DID) lines, which would allow an external party to request a dial tone locally, enabling that person to make unauthorized long-distance phone calls
- Lack of system access controls over long-distance phone calls (e.g., default system vendor passwords unchanged, 24/7 availability of PBX lines)
- Lack of blocking controls for long-distance phone calls to particular numbers (e.g., hot numbers, cellular numbers, etc.)
- Lack of control over the numbers destined for fax machines and modems
- Not activating the option to register calls, which enables the use of call-tracking logs

Although most features are common from PBX to PBX, the implementation of these features may vary and the degree of vulnerability, if any, will depend on how each feature is implemented. For example, many PBX vendors have proprietary designs for the Digital Signaling Protocol between the PBX and the user instruments.

Knowing the design implementation will aid in determining if an intruder or an insider have an easy way to exploit weaknesses or normal functions.

PBX Audit

When planning a PBX audit, the type of skills, the number of auditors and the length of time required to perform the audit cannot be determined without a preliminary assessment of the PBX system, because these depend on the size and complexity of the chosen PBX. The type of perceived threat and the seriousness of any discovered vulnerabilities must be decided by the auditor. Consequently, any corrective actions must also be determined based on the cost of the loss compared with the cost of the corrective action.

A list of critical items of PBX structure, usage and setup will be given, together with specific risk and applicable controls.

PBX System Features

Many features sometimes available to the system may be used by phreakers (security crackers) or intruders for illegal purposes, including:

- Eavesdropping on conversations, without the other parties being aware of it
- Eavesdropping on conference calls
- Illegally forwarding calls from specific instruments to remote numbers
- Forwarding a user's instrument to an unused or disabled number, thereby making it unreachable by external calls

PBX System Attacks

PBX system features and capabilities may present significant vulnerabilities. This occurs because, with such a large number of features available, it becomes difficult for the manufacturer to consider all individual risk and the potential problems caused by the manner in which different features may interact. This may result in vulnerabilities that allow an intruder unwanted access to the PBX and its instruments. **Figure 5.19** shows PBX system features and corresponding risk.

Figure 5.19—PBX System Features and Risk

System Feature	Description	Risk
Automatic call distribution	Allows a PBX to be configured so that incoming calls are distributed to the next available agent or placed on hold until one becomes available	Tapping and control of traffic
Call forwarding	Allows specifying an alternate number to which calls will be forwarded based on certain conditions	User tracking
Account codes	Used to: • Track calls made by certain people or for certain projects for appropriate billing • Dial-in system access (user dials from outside and gains access to the normal features of the PBX)	Fraud, user tracking, nonauthorized features

	• Changing the user class of service so a user can access a different set of features (i.e., the override feature)	
Access codes	Key for access to specific features from the part of users with simple instruments (i.e., traditional analog phones)	Nonauthorized features
Silent monitoring	Silently monitors other calls	Eavesdropping
Conferencing	Allows for conversation among several users	Eavesdropping, by adding unwanted/unknown parties to a conference
Override (Intrude)	Provides for the possibility to break into a busy line to inform another user of an important message	Eavesdropping
Autoanswer	Allows an instrument to automatically go when called—usually gives an audible or visible warning which can easily be turned off.	Gaining information not normally available, for various purposes (i.e., eavesdropping through the automatic answering of an instrument in a conference room)
Tenanting	Limits system user access to only those users who belong to the same tenant group—useful when one company leases out part of its buildings to other companies and tenants share an attendant, trunk lines, etc.	Illegal usage, fraud, eavesdropping
Voice mail	Stores messages centrally and—by using a password—allows for retrieval from inside or outside lines	Disclosure or destruction of all messages of a user when that user's password is known or discovered by an intruder, disabling of the voice mail system and even the entire switch by lengthy messages or embedded codes, illegal access to external lines
Privacy release	Supports shared extensions among several devices, ensuring that only one device at a time can use an extension. Privacy release disables the security by allowing devices to connect to an extension already in use.	Eavesdropping
Nonbusy extensions	Allows calls to an in-use extension to be added to a conference when that extension is on conference and already off-hook	Eavesdropping a conference in progress
Diagnostics	Allows for bypassing normal call restriction procedures. This kind of diagnostic is sometimes available from any connected device. It is a separate feature, in addition to the normal maintenance terminal or attendant diagnostics	Fraud and illegal usage
Camp-on or call waiting	When activated, sends a visual or audible warning to an off-hook instrument that is receiving another call. Another option of this feature is to conference with the camped-on or call-waiting party.	Making the called individual a party to a conference without knowing it
Dedicated connections	Connections made through the PBX without using the normal dialing sequence. It can be used to create hot-lines between devices (i.e., one rings when the other goes off-hook). It is also used for data connections between devices and the central processing facility.	Eavesdropping on a line

Protecting against all of the risk is not easy. Knowing that a given vulnerability in fact exists is already a vital indication. A conservative approach of enabling only the needed features is advisable. Following are some controls to minimize PBX system attacks:

- Where possible, configure and secure separate and dedicated administrative ports.
- Control the definition of DID lines to avoid an external party requesting a dial tone locally, disabling that person's ability to make unauthorized long-distance phone calls.
- Establish system access controls over long-distance phone calls (e.g., change default system vendor passwords, limit the 24/7 availability of PBX lines).
- Block controls for long-distance phone calls to particular numbers (e.g., hot numbers, cellular numbers).
- Establish control over the numbers destined for fax machines and modems.
- Activate the option to register calls, enabling the use of call-tracking logs.

Hardware Wiretapping

A PBX's susceptibility to tapping depends on the methods used for communication between the PBX and its attached devices. This communication may include voice, data and signaling information. The signaling information is typically composed of commands to the devices (e.g., turn on indicators, microphones and speakers) and status from the devices (e.g., hook status and keys pressed). Communications methods use analog voice with or without separate control signals, analog voice with inclusive control signals, and digital voice with inclusive control signals.

Tapping or intrusion in the control sequences is possible using various appropriate hardware technologies, which often include device modification.

The following measures provide controls to minimize risk:

- Physical security of the PBX facilities
- Usage of appropriate anti-tamper devices on critical hardware components

Hardware Conferencing

When implemented in hardware, the conferencing feature may employ a circuit card known as a conference bridge or a signal processor chip. This allows multiple lines to be bridged to create a conference where all parties can both speak and listen. Some PBXs have a mute feature where all parties can hear, but only certain parties can speak. An intruder could try to obtain a connection to the bridge where the conference could be overheard. A hardware modification to the bridge itself may make it possible to cause the output of the bridge available to a specific port. As in device modifications, some additional steps must be taken to receive this information. This may include modifying the database to make the intruder a permanent member of the bridge so any conference on that bridge could be overheard.

The following measures provide controls to minimize risk:

- Establish a strong physical security to prevent unauthorized access to telephone closets and to the PBX facilities. Whenever possible, the PBX should be kept in a locked room with restricted access.
- Lock critical hardware with anti-tamper devices.

Remote Access

Remote access is frequently an unavoidable necessity of maintenance, but it can represent a serious vulnerability. The maintenance features may be accessible via a remote terminal with a modem, a system console or other device or over an outside dial-in line. This allows for systems to be located over a large area (perhaps around the world) and have one central location from which maintenance can be performed. Often it is necessary for the switch manufacturer to have remote access to the switch, to install software upgrades or to restart a switch that has experienced service degradation. Dial-back modem usage is a basic precaution but does not offer full protection. When possible, remote access should be left closed and should be opened only upon need or upon a verified request from the organization that performs the maintenance. It is easy for attackers to contact the switch manufacturer on the pretext of needing help with a particular type of switch, obtain the names of the manufacturer's remote maintenance personnel, and then masquerade as these personnel to obtain access to the victim's switch.

The following measures provide controls to minimize risk:
- A dial-back scheme
- Careful scrutiny and proper authentication of requests to open the remote control

Maintenance
A common maintenance feature is maintenance out of service (MOS). This feature allows maintenance personnel to place a line out of service for maintenance. It is typically used when a problem is detected with a line or when it is desired to disable a line. However, if a line is placed into MOS while it is in operation, the PBX may terminate its signaling communication with the instrument and leave the instrument's voice channel connection active, even after the telephone device is placed on-hook. If the MOS feature were to function in this manner, the potential exists for someone to use the MOS feature to establish a live microphone connection to a user's location without the user's knowledge and, thereby, eavesdrop on the area surrounding the user's telephone.

Another common maintenance feature is the ability to connect two lines together to transmit data from one line to the other and verify whether or not the second line receives the data properly. This feature would allow someone with maintenance access to connect a user's instrument to an instrument at another location to eavesdrop on the area surrounding the user's telephone without the user's knowledge.

Also, the PBX may support some maintenance features that are not normally accessible to the owner/operator of the PBX for several reasons. These types of utilities vary greatly from one PBX to another, so a general approach to finding them cannot be detailed. Some suggested courses of action to verify the existence of such features are listed below:
- Ask the manufacturer or maintenance company if any such features exist.
- Attempt to learn about undocumented usernames/passwords.
- Attempt to search the system's programmable read-only memory (PROM) or disks for evidence of such features.
- View the system load files with a binary editor to determine whether this reveals the names of undocumented commands among a list of known maintenance commands, which can be recognized in the binaries.
- Verify the existence of alarm features.
- Enable and review usage and intervention logs.

Special Manufacturer's Features
These types of features would most likely be accessible via undocumented username/password access to the maintenance and/or administrative tools. Some possible undocumented features and their associated risk are listed below:
- **Database upload/download utility**—This utility allows the manufacturer to download the database from a system that is malfunctioning and examine it at their location to try to determine the cause of the malfunction. It also allows the manufacturer to upload a new database to a PBX in the event that the database became so corrupted that the system became inoperable. Compromise of such a utility could allow an adversary to download a system's database, insert a Trojan horse or otherwise modify it to allow special features to be made available to the adversary, and upload the modified database back into the system.
- **Database examine/modify utility**—This utility allows the manufacturer to remotely examine and modify a system's database to repair damage caused by incorrect configuration, design bugs or tampering. This utility can also provide an intruder with the ability to modify the database to gain access to special features.
- **Software debugger/update utility**—This utility gives the manufacturer the ability to remotely debug a malfunctioning system. It also allows the manufacturer to remotely update systems with bug fixes and software upgrades. It could also grant an adversary the same abilities. This is perhaps the most dangerous vulnerability because access to the software would give an adversary virtually unlimited access to the PBX and its associated instruments.

Manufacturer's Development and Test Features
There may be features that were added to the system during its development phase that were forgotten and not removed when production versions were released. There also may be hidden features that were added by a person on the development team with the intent of creating a back door into the customer's systems. The test features are probably easy to access for ease of development and have few restrictions to reduce development time.

Potential forms of attack include:
- Undocumented username/passwords
- Entering out-of-range values in database fields
- Dialing undocumented access codes on instruments
- Pressing certain key sequences on instruments

Measures that provide controls to minimize risk include:
- Establish strong authentication of external technicians.
- Keep maintenance terminals in a locked, restricted area.
- Turn off maintenance features when not needed, if possible.

Software Loading and Update Tampering
When software is initially loaded onto a PBX and when any software updates/patches are loaded, the PBX is particularly vulnerable to software tampering. A software update sent to a PBX administrator could be intercepted by an adversary. The update could be modified to allow special access or special features to the adversary. The modified update would then be sent to the PBX administrator who would install the update and unknowingly give the adversary unwanted access to the PBX.

A control for software loading and updates would be strong modification—tamper detection based on cryptography used in software packages. Conventional error detection codes, such as checksums or CRCs, are not sufficient to ensure tamper detection.

Crash-restart Attacks
System crashes may indicate a DoS vulnerability. The means by which a system may be crashed vary significantly from one system to another. The following list suggests a few features and conditions that can sometimes trigger a system crash:
- Call forwarding
- Voicemail
- Physical removal of hardware or media from the PBX
- Use of administrative/maintenance terminal functions
- Direct modification of the system or the database. This may be possible if the media can be read by utilities typically found on a PC or workstation.
- Normal system shutdown procedures

These approaches should be tested as possible ways of exposing the weaknesses discussed in the remainder of this section. One possible additional weakness is that a crash may interrupt the control flow and leave microphones open, so an intruder could overhear what is said after the crash. A further danger is that, in some cases, embedded logons and passwords are restored upon rebooting the system, making it possible for a remote operator to complete the remote restart. However, this also makes it possible for an attacker to gain administrator privileges on a system by crashing the system, then applying a known embedded logon ID/password combination.

Controls for these types of attacks include:
- Crash-restart vulnerability tests and preventing or forbidding, if possible, the triggering of events
- Restart procedures that eliminate the vulnerability from loss of control. This may require doing a cold start (i.e., complete shutdown, power-off, and restart) in the event of a system crash.
- If embedded passwords are found, patching the load module to replace them. Authorized manufacturer personnel can be given the new password, if needed.
- A PBX firewall to enhance the protection of the PBX. In recent years, specialized firewalls have been developed specifically for the protection of PBX systems.

Passwords
Most PBXs grant administrative access to the system database through a system console or a generic dumb terminal. Username/password combinations are often used to protect the system from unwanted changes to the database. If remote access to the maintenance features is available, it is usually restricted by some form of password protection. There may be a single fixed maintenance account, multiple fixed maintenance accounts or general user-defined maintenance accounts. The documentation provided with the PBX should state what type of maintenance access is available. The documentation should also indicate how passwords function. Dangers from improper definition and usage of passwords are the loss of control and confidentiality, illegal usage and tampering of the database.

Controls for passwords include:
- Passwords resistant to cracking by automated tools. A password generator that creates random passwords can assist in defeating password crackers.
- Monitoring of multilevel password rights
- Setting an appropriate time-out period for logins

5.5 AUDITING INFORMATION SECURITY MANAGEMENT FRAMEWORK

Auditing the information security framework of an organization involves the audit of logical access, the use of techniques for testing security and the use of investigation techniques.

5.5.1 AUDITING INFORMATION SECURITY MANAGEMENT FRAMEWORK

The information security management framework should be reviewed per the basic elements in an information security framework.

Reviewing Written Policies, Procedures and Standards
Policies and procedures provide the framework and guidelines for maintaining proper operation and control. The IS auditor should review the policies and procedures to determine if they set the tone for proper security and provide a means for assigning responsibility for maintaining a secure computer processing environment. This policy review should also include reviewing the date of the last update to ensure that documents remain current and meet organizational information security needs.

Logical Access Security Policies
These policies should encourage limiting logical access on a need-to-know basis. They should reasonably assess the exposure to the identified concerns.

Formal Security Awareness and Training
Effective security will always be dependent on people. As a result, security can only be effective if employees know what is expected of them and what their responsibilities are. They should know why various security measures, such as locked doors and use of logon IDs, are in place and the repercussions of violating security.

Promoting security awareness is a preventive control. Through this process, employees become aware of their responsibilities for maintaining good physical and logical security. This can also be a detective measure, because it encourages people to identify and report possible security violations.

Training should start with the new employee orientation or induction process. Ongoing awareness can be provided in company newsletters through visible and consistent security enforcement and short reminders during staff meetings. The security administrator should direct the program. To determine the effectiveness of the program, the IS auditor should interview a sample of employees to determine their overall awareness.

Data Ownership
Data ownership refers to the classification of data elements and the allocation of responsibility for ensuring that they are kept confidential, complete and accurate. A key point of ownership is that, by assigning responsibility for protecting computer data to particular employees, accountability is established.

The IS auditor can use this information to determine if proper ownership has been assigned and whether the data owner is aware of the assignment. The IS auditor should also review a sample of job descriptions to ensure that responsibilities and duties are consistent with the information security policy. The auditor should review the classification of data and evaluate their appropriateness, as they relate to the area under review.

Data Owners
Data owners are generally managers and directors responsible for using information for running and controlling the business. Their security responsibilities include authorizing access, ensuring that access rules are updated when personnel changes occur, and regularly review access rules for the data for which they are responsible.

Data Custodians
Data custodians are responsible for storing and safeguarding the data, and include IS personnel such as systems analysts and computer operators.

Security Administrator
Security administrators are responsible for providing adequate physical and logical security for IS programs, data and equipment. (The physical security may be handled by someone else, not always by the security administrator.) Normally, the information security policy will provide the basic guidelines under which the security administrator will operate.

New IT Users
New IT users (employees or third parties) and, in general, all new users assigned PCs or other IT resources should sign a document containing the main IT security obligations that they are thereby engaged to know and observe. These are:
- Reading and agreeing to follow security policies
- Keeping logon IDs and passwords secret
- Creating quality passwords according to policy
- Locking their terminal screens when not in use
- Reporting suspected violations of security
- Maintaining good physical security by keeping doors locked, safeguarding access keys, not disclosing access door lock combinations and questioning unfamiliar people
- Conforming to applicable laws and regulations
- Use of IT resources only for authorized business purposes

Data Users
Data users, including the internal and the external user communities, are the actual users of the computerized data. Their levels of access into the computer should be authorized by the data owners and restricted and monitored by the security administrator. Their responsibilities regarding security are to be vigilant regarding the monitoring of unauthorized people in the work areas and comply with general security guidelines and policies.

Documented Authorizations
Data access should be identified and authorized in writing. The IS auditor can review a sample of these authorizations to determine if the proper level of written authority was provided. If the facility practices data ownership, only the data owners provide written authority.

Terminated Employee Access
Termination of employment can occur in the following circumstances:
- On the request of the employee (voluntary resignation from service)
- Scheduled (on retirement or completion of contract)
- Involuntary (forced by management in special circumstances)

In case of involuntary termination of employment, the logical and physical access rights of employees to the IT infrastructure should either be withdrawn completely or highly restricted as early as possible, before the employee becomes aware of the termination or its likelihood. This ensures that terminated employees cannot continue to access potentially confidential or damaging information from the IT resources or perform any action that would result in damage of any kind to the IT infrastructure, applications and data. Similar procedures should be in place to terminate access for third parties upon terminating their activities with the organization.

When it is necessary for employees to continue to have access, such access must be monitored carefully and continuously and should take place with senior management's knowledge and authorization.

In case of voluntary or scheduled termination of employment, it is management's prerogative to decide whether access is restricted or withdrawn. This depends on:
- The specific circumstances associated with each case
- The sensitivity of the employee's access to the IT infrastructure and resources
- The requirements of the organization's information security policies, standards and procedures

Security Baselines
A baseline security plan is meant to be used as a first step to IT security. The baseline plan should be followed with a full security evaluation and plan. **Figure 5.20** illustrates baseline security topics and their associated recommendations.

Figure 5.21 depicts a checklist for a baseline security evaluation.

Access Standards
Access standards should be reviewed by the IS auditor to ensure they meet organizational objectives for separating duties, prevent fraud or error, and meet policy requirements for minimizing the risk of unauthorized access.

Standards for security may be defined:
- At a generic level (e.g., all passwords must be at least eight characters long)
- For specific machines (e.g., all UNIX machines can be configured to enforce password changes)
- For specific application systems (e.g., sales ledger clerks can access menus that allow entry of sales invoices, but may not access menus that allow check

authorization)

5.5.2 AUDITING LOGICAL ACCESS

When evaluating logical access controls the IS auditor should:

- Obtain a general understanding of the security risk facing information processing, through a review of relevant documentation, inquiry, observation, risk assessment and evaluation techniques
- Document and evaluate controls over potential access paths into the system to assess their adequacy, efficiency and effectiveness by reviewing appropriate hardware and software security features and identifying any deficiencies or redundancies
- Test controls over access paths to determine whether they are functioning and effective by applying appropriate audit techniques
- Evaluate the access control environment to determine if the control objectives are achieved by analyzing test results and other audit evidence
- Evaluate the security environment to assess its adequacy by reviewing written policies, observing practices and procedures, and comparing them with appropriate security standards or practices and procedures used by other organizations

Figure 5.20—IT Security Baseline Recommendations

Topics	Objective	Recommendations
Inventory	Establish and maintain an inventory	Users are expected to follow standards for managing computers connected to the network and have registered network addresses. The OS and owner should be included along with the data provided.
Malware	Install antivirus software with automatic updating	Antivirus software with an automatic DAT file should be updated at regular intervals—no less than weekly.
Passwords	Recognize the importance of passwords	Users must use only strong passwords. The IT department should provide password guidance. Departmental accounts are created for workgroups to prevent/avoid password sharing.
Patching	Make it automatic—less work necessary, less chance for compromise	Each machine should be configured to patch automatically for OS and basic software patching. A process should be set up that works for the department and minimizes disruptions at inconvenient times. Workstations should be more automated to enable system administrators the time to give servers the attention required to minimize the impact on services offered.
Minimizing services offered by systems	Eliminate unnecessary services—reducing security risk and saving time in the long run	To improve basic security and minimize effort to maintain systems, workstations should offer only needed services. Many OSs are installed with services turned on. By removing services, a workstation's chances of being compromised are reduced and security risk is minimized.
Addressing vulnerabilities	Eliminate many vulnerabilities with good system administration	System compromises can be time-consuming and damage credibility and the business's integrity. Information from enterprisewide scans helps to identify vulnerabilities on each system and provide a baseline for comparison when system integrity is in question.
Backups	Allow easy recovery from user mistakes and hardware failure with backups	Backups should be made offsite for increased security.

Figure 5.21—Baseline Security Evaluation Checklist

Topics	Evaluation Questions
Environment/inventory	• What types of data are maintained by the enterprise (e.g., financial, statistical, graphical)? • In what form are they maintained (e.g., spreadsheets, databases, etc.)? • Is there any critical or confidential information maintained or handled? If so, how is it protected? • Are there any specific requirements for handling data? (legal or regulatory requirements) • Have you identified machines that store or require access to confidential information? • What type of operating systems exist? • How many subnets exist? • How many workstations/servers exist? • In how many locations is there IT infrastructure? • Has the wireless infrastructure been deployed? How is it secured? • Is staff instructed on how to lock workstations when they step away? • Are users aware that unexpected email attachments should not be opened? • Is staff aware that many compromises are due to social engineering and the sharing of information? • Does the enterprise have a network diagram that includes IP addresses, room numbers and responsible parties? • Has the enterprise limited and secured physical and remote access to network services? • Is corporate hardware upgraded at regular intervals? • Does the enterprise have a current documented inventory of hardware and software? • Is all corporate software licensed? • Is license documentation available (licenses, purchase orders) if a software audit is required?
Antivirus	• Does the enterprise have an antivirus policy? • Are all workstations running the latest version of antivirus software, the scanning engine and the virus signature file? • Are DAT files downloaded automatically or manually? If manually, how often and why? • Does staff know whom to contact when a virus is found? • Does the antivirus system have a way to defend against zero-day attacks?
Passwords	• Is there a corporate policy requiring strong passwords? • Is the enterprise using software that enforces strong passwords? • Is password caching disabled on all workstations? • Are passwords changed? If so, how often? • Are employees aware that passwords and accounts are not to be shared? • Does the system administrator have written authorization to check for weak passwords?
Patching	• Are software patches applied to all operating systems automatically when possible? If done manually, how often? • Are patches applied to web browsers and applications? If yes, how frequently? • Do you back up each machine before applying a patch? • Do you test patches prior to applying?

	• Does the department have a documented process for patching? • Do you subscribe to sufficient newsletters and groups to be aware of patches to all relevant hardware and software?
Minimizing services offered by systems	• Have you identified services that each user needs to accomplish job assignments? • Have you removed unnecessary services that were installed by default? • Does the technical staff review security settings and policies? • Have you identified what services your systems are offering? • Have you taken security measures for remote access? • Have you transitioned to secure services?
Addressing vulnerabilities/auditing	• Have you resolved vulnerabilities discovered by enterprisewide scans? • Who is the contact for vulnerability scans? • Does the IT staff complete an independent vulnerability scan for the enterprise? • Has the enterprise deployed any form of firewalls or IDS (host or network-based)? Are any under consideration?
Backup and recovery/business continuity	• Are files regularly backed up? • Are files kept onsite in a secure location? • Are backup files sent offsite to a physically secure location? • Are backup files periodically restored as a test to verify whether they are a viable alternative? • Can you ensure that any forms of media containing confidential and sensitive information are sanitized before disposal? • Is there redundant hardware to allow work to continue in the event of a single hardware failure? • Does the enterprise have the ability to continue to function if central services is not available? • Does the enterprise have the ability to continue to function in the event of a wide area network failure? • Have you responded to and recovered from any abuse issues/incidents?
IT staff	• How many IT staff are employed full-time/part-time? • Does each IT staff member have a current job description? • Do job descriptions and evaluations include IT security duties? • Does the department have sufficient documentation to ease the transition of incoming/outgoing staff? • Does the enterprise have a privacy policy? • Are all staff aware of privacy considerations? • Are management/department users aware of the types of (private/nonpublic) information available to systems administrators? • Does the enterprise have a privacy policy to address this privileged information (confidentiality agreement/nondisclosure agreement)? • Does the enterprise have a firewall or IDS, or other software for network diagnosis? Does the enterprise have tools requiring privileges and access to confidential information acquired via routers, switches, IDS, firewalls, etc.?

Familiarization With the IT Environment

This is the first step of the audit and involves obtaining a clear understanding of the technical, managerial and security environment of the IS processing facility. This typically includes interviews, physical walk-throughs, review of documents and risk assessments.

Assessing and Documenting the Access Paths

The access path is the logical route an end user takes to access computerized information. This starts with a terminal/workstation and typically ends with the data being accessed. Along the way, numerous hardware and software components are encountered. The IS auditor should evaluate each component for proper implementation and physical and logical access security.

Special consideration should be given to the:

- Origination and authorization of the data
- Validity and correctness of the input data
- Maintenance of the affected OSs (patching, hardening and closing the unnecessarily open ports)

The typical sequence of the components is as follows:

- A PC, which is part of the LAN, is used by an end user to sign on. The PC should be physically secure and the logon ID/password used for sign-on should be subject to the restrictions identified previously.
  - The OS running on the PC should be patched according to the suggestions of the supplier of the OS and the malware defense must also be updated. Out-of-date OS versions and out-of-date virus defenses can be exploited by attackers. The PC OS must be hardened—deleting the unnecessary services (e.g., those connected with remote procedure calls, sending mail, or network management) and library routines. The parameter settings and configuration of the OS must also be investigated. The ports that are not used should be closed.
- One or more servers from which the applications to be used are invoked. The OS running on the servers should be patched according to the recommendations of the supplier of the OS and the virus defense must also be updated. Out-of-date OS versions and out-of-date virus defenses can be exploited by attackers. The server OS must be hardened—deleting unnecessary services (e.g., those connected with remote procedure calls, sending mail, or network management) and library routines. The parameter settings and configuration of the OS must also be investigated. The ports that are not used should be closed.
- The telecommunications software (LAN server or terminal emulator if connecting to a mainframe) intercepts the logon to direct it to the appropriate telecommunication link. The telecommunication software can restrict PCs to specific data or application software. A key audit issue with telecommunication software is to ensure that all applications have been defined within the software and that the various optional telecommunication control and processing features used are appropriate and approved by management. This analysis typically requires the assistance of a system software analyst.
- The transaction processing software may be the next component in the access path. This software routes transactions to the appropriate application software. Key audit issues include ensuring proper identification/authentication of the user (logon ID and password) and authorization of the user to gain access to the application. This analysis is performed by reviewing internal tables that reside in the transaction processing software or in separate security software. Access to these should be restricted to the security administrator.
- The application software then is encountered and should process transactions in accordance with program logic. Audit issues include restricting access to the production software library to only the implementation coordinator.
- The database management system (DBMS) directs access to the computerized information. Audit issues include ensuring that all data elements are identified in the data dictionary, that access to the data dictionary is restricted to the database administrator (DBA) and that all data elements are subject to logical access control. The application data now can be accessed.
- The access control software can wrap logical access security around all of the above components. This is done via internal security tables. Audit issues include ensuring all of the above components are defined to the access control software, providing access rules that define who can access what on a need-to-know basis and restricting security table access to the security administrator.

Note: The development of the application systems must be disciplined. The IS auditor should evaluate the control objectives, referring to the origination and authorization of the applications data, and should evaluate the control measures used in data input and processing. Omitting these control objectives and measures makes the applications vulnerable to attacks either from within or from the outside, especially from the Internet. Firewalls do not protect applications against the types of attacks that come with the HTTP communication that is usually permitted on the applications.

Interviewing Systems Personnel
To control and maintain the various components of the access path, as well as the OS and computer mainframe, technical experts often are required. These people can be a valuable source of information to the IS auditor when gaining an understanding of security. To determine who these people are, the IS auditor should meet with the IS manager and review organizational charts and job descriptions. Key people include the security administrator, network control manager and systems software manager.

The security administrator should be asked to identify the responsibilities and functions of the position. If the answers provided to this question do not support sound control practices or do not adhere to the written job description, the IS auditor should compensate by expanding the scope of the testing of access controls. Also, the IS auditor should determine whether the security administrator is aware of the logical accesses that must be protected, has the motivation and means to actively monitor logons to account for employee changes, and is knowledgeable in how to maintain and monitor access.

A sample of end users should be interviewed to assess their awareness of management policies regarding logical security and confidentiality.

Reviewing Reports From Access Control Software
The reporting features of access control software provide the security administrator with the opportunity to monitor adherence to security policies. By reviewing a sample of security reports, the IS auditor can determine whether enough information is provided to support an investigation and if the security administrator is performing an effective review of the report.

Unsuccessful access attempts should be reported and should identify the time, terminal, logon and file or data element for which access was attempted.

Reviewing Application Systems Operations Manual
An application systems manual should contain documentation on the programs that generally are used throughout a data processing installation to support the development, implementation, operations and use of application systems. This manual should include information about the platform the application can run on, DBMSs, compilers, interpreters, telecommunication monitors and other applications that can run with the application.

5.5.3 TECHNIQUES FOR TESTING SECURITY

Auditors can use different techniques for testing security. Some methods are described in the following subsections.

Terminal Cards and Keys
The IS auditor can take a sample of these cards or keys and attempt to gain access beyond that which is authorized. Also, the IS auditor will want to know if the security administrator followed up on any unsuccessful attempted violations.

Terminal Identification
The IS auditor can work with the network manager to get a listing of terminal addresses and locations. This list can then be used to inventory the terminals, looking for incorrectly logged, missing or additional terminals. The IS auditor should also select a sample of terminals to ensure that they are identified in the network diagram.

Logon IDs and Passwords
To test confidentiality, the IS auditor could attempt to guess the password of a sample of employees' logon IDs (although this is not necessarily a test). This should be done discreetly to avoid upsetting employees. The IS auditor should tour end-user and programmer work areas looking for passwords taped to the side of terminals, the inside of desk drawers or located in card files. Another source of confidential information is the wastebasket. The IS auditor might consider going through the office wastebasket looking for confidential information and passwords. Users could be asked to give their password to the IS auditor. However, unless specifically authorized for a particular situation and supported by the security policy, no user should ever disclose his/her password. Another way to test password strength is to analyze global configuration settings for password strength in the system application and compare this with the organization's security policy.

To test encryption, the IS auditor should work with the security administrator to attempt to view the internal password table. If viewing is possible, the contents should be unreadable. Being able to view encrypted passwords can still be dangerous. Although passwords on some systems are impossible to decipher, if an individual can obtain the encryption program, they can encrypt common passwords and look for matches. This was a method used to break into UNIX computers prior to the development of shadow password files. Application logs should also be reviewed to ensure that passwords and logon IDs are not recorded in a clear form.

To test access authorization, the IS auditor should review a sample of access authorization documents to determine if proper authority has been provided and if the authorization was granted on a need-to-know basis. Conversely, the IS auditor should get a computer-generated report of computer access rules, take a sample to determine if the access is on a need-to-know basis, and attempt to match the sample of these rules to authorizing documents. If no written authorization is found, this indicates a breakdown in control and may warrant further review to determine the exposures and implications.

Account settings for minimizing unauthorized access should be available from most access control software or from the OS. To verify that these settings actually are working, the IS auditor can perform the following manual tests:
- To test periodic change requirements, the IS auditor can draw on his/her experiences using the system and interview a sample of users to determine if they are forced to change their password after the prescribed time interval.
- To test for disabling or deleting of inactive logon IDs and passwords, the IS auditor should obtain a computer-generated list of active logon IDs. On a sample basis, the IS auditor should match this list to current employees, looking for logon IDs assigned to employees or consultants who are no longer with the company.
- To test for password syntax, the IS auditor should attempt to create passwords in a format that is invalid, such as too short, too long, repeated from the previous password, incorrect mix of alpha or numeric characters, or the use of inappropriate characters.
- To test for automatic logoff of unattended terminals, the IS auditor should log on to a number of terminals. The IS auditor then simply waits for the

terminals to disconnect after the established time interval. Before beginning this test, the IS auditor should verify with the security administrator that this automatic logoff feature applies to all terminals.
- To test for automatic deactivation of terminals after unsuccessful access attempts, the IS auditor should attempt to log on, purposefully entering the wrong password a number of times. The logon ID should deactivate after the established number of invalid passwords has been entered. The IS auditor will be interested in how the security administrator reactivates the logon ID. If a simple telephone call to the security administrator with no verification of identification results in reactivation, then this function is not controlled properly.
- To test for masking of passwords on terminals, the IS auditor should log on to a terminal and observe if the password is displayed when entered.

Controls Over Production Resources
Computer access controls should extend beyond application data and transactions. There are numerous high-level utilities, macro or job control libraries, control libraries, and system software parameters for which access control should be particularly strong. Access to these libraries would provide the ability to bypass other access controls.

The IS auditor should work with the system software analyst and operations manager to determine if access is on a need-to-know basis for all sensitive production resources. Working with the security administrator, the IS auditor should determine who can access these resources and what can be done with this access.

Logging and Reporting of Computer Access Violations
To test the reporting of access violations, the IS auditor should attempt to access computer transactions or data for which access is not authorized. The attempts should be unsuccessful and identified on security reports. This test should be coordinated with the data owner and security administrator to avoid violation of security regulations.

Follow-up Access Violations
To test the effectiveness and timeliness of the security administrator and data owner's responses to reported violation attempts, the IS auditor should select a sample of security reports and look for evidence of follow-up and investigation of access violations. If such evidence cannot be found, the IS auditor should conduct further interviews to determine why this situation exists.

Bypassing Security and Compensating Controls
This is a technical area of review. As a result, the IS auditor should work with the system software analyst, network manager, operations manager and security administrator to determine ways to bypass security. This typically includes bypass label processing, special system maintenance logon IDs, OS exits, installation utilities and input/output (I/O) devices. Working with the security administrator, the IS auditor should determine who can access these resources and what can be done with this access. The IS auditor should determine if access is on a need-to-know/have basis or if compensating detective controls exist.

There should be restrictions and procedures of monitoring access to computer features that bypass security. Generally, only system software programmers should have access to these features:
- **Bypass label processing (BLP)**—BLP bypasses the computer reading of the file label. Because most access control rules are based on file names (labels), this can bypass access control programs.
- **System exits**—This system software feature permits the user to perform complex system maintenance, which may be tailored to a specific environment or company. They often exist outside of the computer security system and, thus, are not restricted or reported in their use.
- **Special system logon IDs**—These logon IDs often are provided by vendors. The names can be determined easily because they are the same for all similar computer systems (i.e., "system"). Passwords should be changed immediately upon installation to secure the systems.

Because many of these bypassing security features can be exploited by technically sophisticated intruders, the IS auditor should also ensure that:
- All uses of these features are logged, reported and investigated by the security administrator or system software manager
- Unnecessary bypass security features are deactivated
- If possible, the bypass security features are subject to additional logical access controls

Review Access Controls and Password Administration
Access controls and password administration are reviewed to determine that:
- Procedures exist for adding individuals to the list of those authorized to have access to computer resources, changing their access capabilities and deleting them from the list.
- Procedures exist to ensure that individual passwords are not inadvertently disclosed.
- Passwords issued are of an adequate length, cannot be easily guessed and do not contain repeating characters.
- Passwords are periodically changed.
- User organizations periodically validate the access capabilities currently provided to individuals in their department.
- Procedures provide for the suspension of user identification codes (logon IDs or accounts) or the disabling of terminal, microcomputer or data entry device activity—after a particular number of security procedure violations.

5.5.4 INVESTIGATION TECHNIQUES
Investigation techniques include the investigation of computer crime and the protection of evidence and chain of custody, among others.

Investigation of Computer Crime
Computer crimes are not reported in most cases because they are not detected. In many cases where computer crimes are detected, companies hesitate to report them because they generate a large amount of negative publicity that can affect their business. In such cases, the management of the affected company seeks to fix the vulnerabilities used for the crime and resume operations. In addition, in many countries current laws are directed toward protecting physical property. It is very difficult to use such laws against computer crime. Even in jurisdictions where the laws have been updated, the investigation procedures are not always widely known and the necessary hardware and software tools are not always available to collect the digital evidence.

In the aftermath of a computer crime, it is very important that proper procedures are used to collect evidence from the crime scene. If data and evidence is not collected in the proper manner, it could be damaged and, even if the perpetrator is eventually identified, prosecution will not be successful in the absence of undamaged evidence. Therefore, after a computer crime, the environment and evidence must be left unaltered and specialist law enforcement

officials must be called in. If the incident is to be handled in-house, the company must have a suitably qualified and experienced incident response team.

Computer Forensics
Computer forensics is defined as the "process of identifying, preserving, analyzing and presenting digital evidence in a manner that is legally acceptable in any legal proceedings (i.e., a court of law)," according to D. Rodney McKemmish in Computer and Intrusion Forensics. An IS auditor may be required or asked to be involved in a forensic analysis in progress to provide expert opinion or to ensure the correct interpretation of information gathered.

Computer forensics includes activities that involve the exploration and application of methods to gather, process, interpret and use digital evidence that help to substantiate whether an incident happened such as:
- Providing validation that an attack actually occurred
- Gathering digital evidence that can later be used in judicial proceedings

Any electronic document or data can be used as digital evidence, provided there is sufficient manual or electronic proof that the contents of digital evidence are in their original state and have not been tampered with or modified during the process of collection and analysis.

It is very important to preserve evidence in any situation. Most organizations are not well equipped to deal with intrusions and electronic crimes from an operational and procedural perspective, and they respond to it only when the intrusion has occurred and the risk is realized. The evidence loses its integrity and value in legal proceedings if it has not been preserved and subject to a documented chain of custody. This happens when the incident is inappropriately managed and responded to in an ad hoc manner.

For evidence to be admissible in a court of law, the chain of custody needs to be maintained professionally. The chain of evidence essentially contains information regarding:
- Who had access to the evidence (chronological manner)
- The procedures followed in working with the evidence (e.g., disk duplication, virtual memory dump)
- Proving that the analysis is based on copies that are identical to the original evidence (e.g., documentation, checksums or timestamps)

It is important to use industry-specified good practices, proven tools and due diligence to provide reasonable assurance of the quality of evidence.

It is also important to demonstrate integrity and reliability of evidence for it to be acceptable to law enforcement authorities. For example, if the IS auditor "boots" a computer suspected of containing stored information that might represent evidence in a court case, the auditor cannot later deny that they wrote data to the hard drive because the boot sequence writes a record to the drive. This is the reason specialist tools are used to take a true copy of the drive, which is then used in the investigation.

There are four major considerations in the chain of events in regards to evidence in computer forensics:
- **Identify**—Refers to the identification of information that is available and might form the evidence of an incident.
- **Preserve**—Refers to the practice of retrieving identified information and preserving it as evidence. The practice generally includes the imaging of original media in presence of an independent third party. The process also requires being able to document chain-of-custody so that it can be established in a court of law.
- **Analyze**—Involves extracting, processing and interpreting the evidence. Extracted data could be unintelligible binary data after it has been processed and converted into human readable format. Interpreting the data requires an in-depth knowledge of how different pieces of evidence may fit together. The analysis should be performed using an image of media and not the original.
- **Present**—Involves a presentation to the various audiences such as management, attorneys, court, etc. Acceptance of the evidence depends upon the manner of presentation (as it should be convincing), qualifications of the presenter, and credibility of the process used to preserve and analyze the evidence.

The IS auditor should give consideration to key elements of computer forensics during audit planning. These key elements are described in the following subsections.

DATA PROTECTION
To prevent sought-after information from being altered, all measures must be in place. It is important to establish specific protocols to inform appropriate parties that electronic evidence will be sought and to not destroy it by any means.

Infrastructure and processes for incident response and handling should be in place to permit an effective response and forensic investigation if an event or incident occurs.

DATA ACQUISITION
All information and data required should be transferred into a controlled location; this includes all types of electronic media such as fixed disk drives and removable media. Each device must be checked to ensure that it is write-protected. This may be achieved by using a device known as a write-blocker.

It is also possible to get data and information from witnesses or related parties by recorded statements.

By volatile data, investigators can determine what is currently happening on a system. This kind of data includes open ports, open files, active processes, user logons and other data present in RAM. This information is lost when the computer is shut down.

IMAGING
Imaging is a process that allows one to obtain a bit-for-bit copy of data to avoid damage of original data or information when multiple analyses may be performed. The imaging process is made to obtain residual data, such as deleted files, fragments of deleted files and other information present, from the disk for analysis. This is possible because imaging duplicates the disk surface, sector by sector.

With appropriate tools, it is sometimes possible to recover destroyed information (erased even by reformatting) from the disk's surface.

EXTRACTION
This process consists of identification and selection of data from the imaged data set. This process should include standards of quality, integrity and reliability. The extraction process includes software used and media where an image was made.

The extraction process could include different sources such as system logs, firewall logs, IDS logs, audit trails and network management information.

INTERROGATION
Interrogation is used to obtain prior indicators or relationships, including telephone numbers, IP addresses and names of individuals, from extracted data.

INGESTION/NORMALIZATION
This process converts the information extracted to a format that can be understood by investigators. It includes conversion of hexadecimal or binary data into readable characters or a format suitable for data analysis tools.

It is possible to create relationships from data by extrapolation, using techniques such as fusion, correlation, graphing, mapping or time lining, which could be used in the construction of the investigation's hypothesis.

REPORTING
The information obtained from computer forensics has limited value when it is not collected and reported in the proper way.

When an IS auditor writes the report, he/she must include why the system was reviewed, how the computer data were reviewed and what conclusions were made from this analysis.

The report should achieve the following goals (from Mandia, Kevin; Matt Pepe; Chris Prosise; *Incident Response & Computer Forensics, 2nd Edition*, McGraw Hill/Osborne, USA, 2003):
- Accurately describe the details of an incident
- Be understandable to decision-makers
- Be able to withstand a barrage of legal scrutiny
- Be unambiguous and not open to misinterpretation
- Be easily referenced
- Contain all information required to explain conclusions reached
- Offer valid conclusions, opinions or recommendations when needed
- Be created in a timely manner

The report should also identify the organization, sample reports and restrictions on circulation (if any) and include any reservations or qualifications that the IS auditor has with respect to the assignment.

Protection of Evidence and Chain of Custody
The evidence of a computer crime exists in the form of log files, file time stamps, contents of memory, etc. Rebooting the system or accessing files could result in such evidence being lost, corrupted or overwritten. Therefore, one of the first steps taken should be copying one or more images of the attacked system. Memory content should also be dumped to a file before rebooting the system. Any further analysis must be performed on an image of the system and on copies of the memory dumped—not on the original system in question.

In addition to protecting the evidence, it is also important to preserve the chain of custody. Chain of custody refers to documenting, in detail, how evidence is handled and maintained, including its ownership, transfer and modification. This is necessary to satisfy legal requirements that mandate a high level of confidence regarding the integrity of evidence.

5.6 AUDITING NETWORK INFRASTRUCTURE SECURITY

When performing an audit of the network infrastructure, the IS auditor should:
- Review network diagrams (campus LAN networks, WANS, metropolitan area networks [MANs]) that identify the organizations internetworking infrastructure, which would include gateways, firewalls, routers, switches, hubs, access servers, modems, etc. This information is important because the IS auditor will want to evaluate these links to determine whether proper physical and logical access controls are in effect and to inventory the various terminal connections to ensure that the diagram is accurate.
- Identify the network design implemented, including the IP strategy used, segmentation of routers and switches for campus environments, and WAN configurations and protocols.
- Determine that applicable security policies, standards, procedures and guidance on network management and usage exist and have been distributed to staff, network management and administration. He/she should also ensure that staff members have been trained in their duties and responsibilities.
- Identify who is responsible for security and operation of Internet connections, and evaluate whether they have sufficient knowledge and experience to undertake this role.
- Determine whether consideration has been given to the legal problems arising from use of the Internet. Considerations should include liability arising from inaccurate web pages; legislation regarding sale or advertising of regulated products, such as financial services; implications of selling/buying in different countries; and the state of application of standard contract terms to electronic trading.
- Determine whether a vulnerability scanning process is in place. Vulnerability scanning refers to an automated process to proactively identify security weaknesses in a network or individual system. It can detect known vulnerabilities and recommend patches, upgrades, fixes or workarounds.
- If the service is outsourced, review SLAs to ensure that they include provisions for security in addition to availability and quality of service.
- Review network administrator procedures to ensure that hardware and software components are upgraded in response to new vulnerabilities.
- Review the transmission medium used for the LAN and its physical security protection to establish vulnerability to wiretapping.
- Review the network topological design to ensure it is sufficiently resilient to maintain business continuity in the event of disruption (e.g., a ring network is more resilient than a star).
- Review the network design to identify single points of failure, such as all WAN connections entering a building at the same place.

5.6.1 AUDITING REMOTE ACCESS

Remote use of information resources dramatically improves business productivity but generates control issues and security concerns. IS auditors should determine that all remote access capabilities used by an organization provide for effective security of the organization's information resources. Remote access security controls should be documented and implemented for authorized users operating outside of the trusted network environment.

In reviewing existing remote access architectures, IS auditors should assess remote access points of entry in addressing how many (known/unknown) exist and whether greater centralized control of remote access points is needed. IS auditors should also review access points for appropriate controls, such as in the use of VPNs, authentication mechanisms, encryption, firewalls and IDSs.

As part of this review, the IS auditor should also test dial-up access controls. To test for dial-up access authorization, the IS auditor should dial the computer from a number of authorized and unauthorized telephone lines. If controls are adequate, successful connection will occur with the authorized numbers only. The IS auditor should test the logical controls invoked after authorized connections to the computer are achieved by using the successful dial-up connections to attempt to gain unauthorized file access. Performance of this test should be coordinated through the security administrator to avoid violating security regulations.

In reviewing future remote access initiatives, IS auditors should first determine whether design and development of remote access approaches are based on a cost-effective, risk-based solution taking into account business requirements. This includes assessing the types of remote environments applicable, the integrity and availability of telecommunication services, and required measures to take in protecting the corporate infrastructure.

Auditing Internet Points of Presence

When auditing an organization's presence on the Internet, the IS auditor should review the use of the Internet to ensure that a business case has been demonstrated for the following possible uses:

- Email (i.e., communications to/from business partners, customers and the general public)
- Marketing (e.g., mechanism for communicating customer values such as online home shopping catalogue)
- Sales channel/electronic commerce (e.g., electronic ordering of goods/services, purchasing of goods from home shopping catalogue using credit cards or electronic transmission of standard electronic data interchange (EDI)-formatted order messages by business partners)
- Channel of delivery for goods/services (such as online bookstores and Internet banking)
- Information gathering (e.g., staff browsing the web for information)

Network Penetration Tests

Combinations of procedures, whereby an IS auditor uses the same techniques as a hacker, are called penetration tests, intrusion tests or ethical hacking. These are effective methods of identifying the real-time risk to an information processing environment. During penetration testing, an auditor attempts to circumvent the security features of a system and exploits the vulnerabilities to gain access that would otherwise be unauthorized.

Scope can vary based on the terms and conditions of the client and requirements. However, from an audit risk perspective, the following should be mentioned clearly in the audit scope:

- Precise IP addresses/ranges to be tested
- Host restricted (i.e., hosts not to be tested)
- Acceptable testing techniques (i.e., social engineering, DoS/distributed denial of service [DDoS], SQL injections, etc.)
- Acceptance of proposed methodology from management
- Timing of attack simulation (i.e., business hours, off hours, etc.)
- IP addresses of the source of attack simulation (to identify between approved simulated attack and actual attack)
- Point of contact for both the penetration tester/auditor and the targeted system owner/administrator
- Handling of information collected by the penetration tester/auditor (i.e., nondisclosure agreement [NDA] or reference to standard rules of engagement)
- Warning notification from penetration tester/auditor, before the simulation begins to avoid false alarms to law enforcement bodies

The different phases of penetration testing appear in **figure 5.22** and the corresponding procedures in **figure 5.23**.

Penetration testing is intended to mimic an experienced hacker attacking a live site. It should only be performed by experienced and qualified professionals who are aware of the risk of undertaking such work and can limit the damage resulting from a successful break-in to a live site (e.g., avoidance of DoS attacks). It is a simulation of a real attack and maybe restricted by the law, an organization's policy and federal regulations; therefore, it is imperative to obtain management's consent in writing before finalization of the test/engagement scope.

Figure 5.22—Penetration Testing Phases

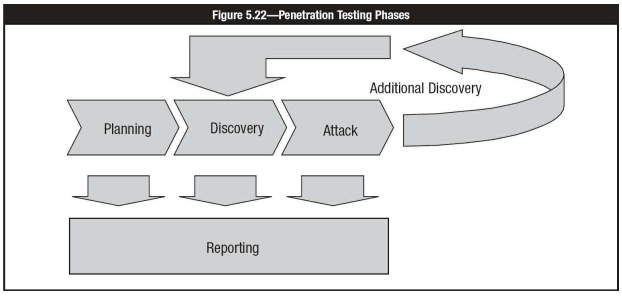


Figure 5.23—Penetration Testing Phases and Procedures

Phase	Procedures
Planning	• Rules of engagement • Management approval/finalization • Adopted testing methodology • Intrusive or nonintrusive testing • Goals/objectives identified and agreed upon • Timelines/deadlines agreed upon • Milestones identified • Assignment time tracking technique understood and communicated • Deliverables agreed upon • Tools collected/installed/tested in a test environment

Reconnaissance/discovery	• Network mapping • DNS interrogation • WHOIS queries • Searching target's web site for information • Searching target's related data on search engines • Searching target's related data and employees on social media (reveals system related details) • Searching resume/curriculum vitae of target's current and formal employees (reveals system related details) • Packet capture/sniffing (during internal testing only) • Host detection (Internet control message protocol [ICMP], DNS, WHOIS, PingSweep, TCP/UDP Sweep, etc.) • Service detection (port scanning, stealth scanning, error/banner detection, etc.) • Network topology detection (ICMP, etc.) • OS detection (TCP stack analysis, etc.) • Web site mapping • Web page analysis • Unused pages/scripts • Broken links • Hidden links/files accessible • Application logic/use • Points of input error page banner grabbing • Vulnerability classification (based on information collected in previous steps, vulnerabilities are searched on available search engines or custom-built repositories) Some of the attack techniques are as follows: • Directory browsing • Show code • Error injection • Type and bound checks on input
Attacks	• Special character injection (meta-characters, escape characters, etc.) • Cookie/session IDs analysis • Authentication circumvention • Long input • System functions (shell escapes, etc.) • Logic alteration (SQL injection, etc.) • Cookie/session IDs manipulation • Internet service exploits (bind, mdac, unicode, apache-http, statd, sadmind, etc.) • OS exploits • Network exploits (SYN flooding, ICMP redirects, DNS poisoning, etc.) Furthermore, once an attack is successful, it typically follows these subprocedures of an attack phase: • Privilege escalation—If only a user-level access was gained previously, then the tester will attempt to obtain super-level access (i.e., root on UNIX/Linux and administrator on Windows) • Information gathering from inside—The attacker will probe further systems on the network efficiently utilizing the compromised system as a launch pad and thereby attempt to gain access to trusted/high-risk systems. • Installation of further attack tools inside the system—Attacker may require installation of additional tools and penetration testing software to gain further access to the resources, trusted or high-risk systems.
Reporting	This phase simultaneously occurs with the rest of the three phases. In the planning phase, rules of engagement, written consent and test plans are developed, discussed and reported. In the discovery phase, written logs are kept and periodic reports on the status of assignment are reported to management, as appropriate. Following the attack phase, the vulnerabilities and weaknesses discovered are reported with risk rating based on probability derived from ease of exploitation and impact derived from attack results or official advisories and resources from the vendor. In addition, the recommendations contain steps to mitigate the risk and to effectively rectify the weaknesses.

There are several types of penetration tests depending upon the scope, objective and nature of the test. Generally accepted and common types of penetration tests are:

- **External testing**—Refers to attacks and control circumvention attempts on the target's network perimeter from outside the target's system (i.e., usually the Internet)
- **Internal testing**—Refers to attacks and control circumvention attempts on the target from within the perimeter. The objective is to identify what would occur if the external network perimeter was successfully compromised and/or an authorized user from within the network wanted to compromise security of a specific resource on the network.
- **Blind testing**—Refers to the condition of testing when the penetration tester is provided with limited or no knowledge of the target's information systems. Such testing is expensive, because penetration testers have to research the target and profile it based on publicly available information only.
- **Double blind testing**—Refers to an extension of blind testing, because the administrator and security staff at the target are also not aware of the test. Such testing can effectively evaluate the incident handling and response capability of the target.
- **Targeted testing**—Refers to attacks and control circumvention attempts on the target, while both the target's IT team and penetration testers are aware of the testing activities. Penetration testers are provided with information related to target and network design. Additionally, they may also be provided with a limited-privilege user account to be used as a starting point to identify privilege-escalation possibilities in the system.

Although management may sponsor the activities of penetration testing, some of the associated risk includes the following:

- Penetration testing does not provide assurance that all vulnerabilities are discovered and may fail to discover significant vulnerabilities.
- Miscommunication may result in the test objectives not being achieved.
- Testing activities may inadvertently trigger escalation procedures that may not have been appropriately planned.
- Sensitive information may be disclosed, heightening the target's exposure level.
- Without proper background and qualification checks of penetration testers, the penetration tester may damage the information assets or misuse the information gained for personal benefits.

Additionally, these techniques are becoming more popular for testing the reliability of firewall access controls. The IS auditor should be extremely careful

if attempting to break into a live production system because, if successful, the IS auditor may cause the system to fail. Permission for the use of such techniques should always be obtained from top-level senior management. Permission from top-level senior management is also required to determine what other tests can be performed without informing the staff who are responsible for the monitoring and reporting of security violations (if any are aware that the attack will take places, they are likely to be more vigilant than normal).

Full Network Assessment Reviews

Upon completion of penetration testing, comprehensive review of all network system vulnerabilities should occur to determine whether threats to confidentiality, integrity and availability have been identified. The following reviews should occur:

- Security policy and procedures should be reviewed to determine good practices are in place.
- The network and firewall configuration should be evaluated to ensure that they have been designed to support the security of the services being provided (e.g., screening routers, dual/multihomed host, screened subnet, demilitarized zone proxy servers).
- The logical access controls should be evaluated to ensure that they support segregation of duties (e.g., development vs. operation, security administration vs. audit).
- The following should be determined:
  - Intrusion detection software is in place.
  - Filtering is being performed.
  - Encryption is being used (consider VPNs/tunneling, digital signatures for email, etc.).
  - Strong forms of authentication are being used (consider use of smart cards, biometrics, etc., for authentication to firewalls, to internal software/hardware within the network, and to external hardware/software).
  - The firewalls have been configured properly (consider removal of all unnecessary software, addition of security and auditing software, removal of unnecessary logon IDs, disabling of unused services).
  - The application- or circuit-level gateways in use are running proxy servers for all legitimate services (e.g., teletype network [Telnet], HTTP, FTP).
  - Virus scanning is being used.
  - Periodic penetration testing is being completed.
  - Audit logging is undertaken for all key systems (e.g., firewalls, application gateways, routers, etc.) and audit logs are copied to secure file systems (consider the use of SIEM software).
  - The security administrators are keeping up to date with the latest known vulnerabilities via the organizations' vendors, their local and international CERT, and vulnerability databases (e.g., the National Vulnerability Database operated by the NIST).

Development and Authorization of Network Changes

Network configuration changes to update telecommunications lines, terminals, modems and other network devices should be authorized in writing by management and implemented in a timely manner. The IS auditor can test this change control by:

- Sampling recent change requests, looking for appropriate authorization and matching the request to the actual network device
- Matching recent network changes, such as new telecommunication lines, to added terminals and authorized change requests

As an added control, the IS auditor should determine who can access the network change software. This access should be restricted to senior network administrators.

Specific development and change control procedures should be in place for network components' hardware and software. Procedures should cover:

- Firewalls
- Routers
- Switches
- Application gateways
- DNS/network topology
- Client software
- Network management software
- Web server hardware and configuration
- Application software
- Web pages

Unauthorized Changes

One of the most important objectives of change control procedures is to prevent or detect unauthorized changes to software, configurations or parameters, and data. Unauthorized changes include any changes to software or configurations/parameters that occur without conforming to change control procedures. They include situations where changes are made to software code without authorization, in addition to legitimate changes made in accordance with change control procedures.

Controls to prevent unauthorized changes to software and software configurations include:

- SoD between software development, software administration and computer operations
- Restricting the software development team's access to the development environment only
- Restricting access to the software source codes

Controls to detect unauthorized changes to software include software code comparison utilities. Unauthorized changes to configurations/parameters can be detected through logging and monitoring system administrator activities.

Changes to data normally are controlled through the applications. Application access control mechanisms and built in application controls normally prevent unauthorized access to data. These controls can be circumvented by direct access to data. For this reason, direct access to data (specifically "write" or "change" access) should be restricted and monitored.

5.7 ENVIRONMENTAL EXPOSURES AND CONTROLS

As with any other manmade objects, IT infrastructure and, hence, information assets are exposed to the environment. The IS auditor should be aware of these exposures and the controls used to mitigate them.

5.7.1 ENVIRONMENTAL ISSUES AND EXPOSURES

Environmental exposures are due primarily to naturally occurring events such as lightning storms, earthquakes, volcanic eruptions, hurricanes, tornados and other types of extreme weather conditions. The result of such conditions can lead to many types of problems. One particular area of concern is power failures of computer and supporting environmental systems. Generally, power failures can be grouped into four distinct categories, based on the duration and relative severity of the failure:

- **Total failure (blackout)**—A complete loss of electrical power, which may span from a single building to an entire geographical area and is often caused by weather conditions (e.g., storm, earthquake) or the inability of an electrical utility company to meet user demands (e.g., during summer months)
- **Severely reduced voltage (brownout)**—The failure of an electrical utility company to supply power within an acceptable range (i.e., 108-125 volts AC in the US). Such failure places a strain on electronic equipment and may limit their operational life or even cause permanent damage.
- **Sags, spikes and surges**—Temporary and rapid decreases (sags) or increases (spikes and surges) in voltage levels. These anomalies can cause loss of data, data corruption, network transmission errors or physical damage to hardware devices (e.g., hard disks or memory chips).
- **Electromagnetic interference (EMI)**—Caused by electrical storms or noisy electrical equipment (e.g., motors, fluorescent lighting, radio transmitters). This interference may cause computer systems to hang or crash as well as damages similar to those caused by sags, spikes and surges.

Short-term interruptions, such as sags, spikes and surges, which last from a few millionths to a few thousandths of a second, can be prevented by using properly placed surge protectors. Intermediate-term interruptions, which last from a few seconds to 30 minutes, can be controlled by UPS devices. Finally, long-term interruptions, which last from a few hours to several days, require the use of alternate power generators. These generators may be portable devices or part of the building's infrastructure and are powered by alternative sources of energy such as diesel, gasoline or propane.

Another area of concern deals with water damage/flooding. This is a concern even with facilities located on upper floors of high-rise buildings because water damage typically occurs from broken water pipes.

Manmade concerns include terrorist threats/attacks, vandalism, electrical shock and equipment failure.

Some questions that organizations must address related to environmental issues and exposures include the following:

- Is the power supply to the computer equipment properly controlled to ensure that power remains within the manufacturer's specifications?
- Are the air conditioning, humidity and ventilation control systems for the computer equipment adequate to maintain temperatures within manufacturers' specifications?
- Is the computer equipment protected from the effects of static electricity, using an antistatic rug or antistatic spray?
- Is the computer equipment kept free of dust, smoke and other particulate matter such as food?
- Do policies exist that prohibit the consumption of food, beverage and tobacco products near computer equipment?
- Are backup media protected from damage due to temperature extremes, the effects of magnetic fields and water damage?

5.7.2 CONTROLS FOR ENVIRONMENTAL EXPOSURES

Environmental exposures should be afforded the same level of protection as physical and logical exposures.

Alarm Control Panels

An alarm control panel should ideally be:

- Separated from burglar or security systems located on the premises
- Accessible to fire department personnel at all times
- Located in a weatherproof box
- In accordance with temperature requirements set by the manufacturer
- Situated in a controlled room to prevent access by unauthorized personnel
- Allocated power from a dedicated and separate circuit
- Able to control or disable separate zones within the facilities
- In adherence with local and national regulations and approved by local authorities

Water Detectors

In the computer room, water detectors should be placed under raised floors and near drain holes, even if the computer room is on a high floor (because of possible water leaks). Any unattended equipment storage facilities should also have water detectors. When activated, the detectors should produce an audible alarm that can be heard by security and control personnel. The location of the water detectors should be marked on the raised computer room floor for easy identification and access. On hearing the alarm, specific individuals should be responsible for investigating the cause and initiating remedial action; other staff should be made aware by security and control personnel that there is a risk of electric shock.

Handheld Fire Extinguishers

Fire extinguishers should be in strategic locations throughout the facility. They should be tagged for inspection and inspected at least annually.

Manual Fire Alarms

Hand-pull fire alarms should be placed strategically throughout the facility. These are normally located near exit doors to ensure personnel safety. The resulting audible alarm should be linked to a monitored guard station.

Smoke Detectors

Smoke detectors should be installed above and below the ceiling tiles throughout the facilities and below the raised computer room floor. The detectors should produce an audible alarm when activated and be linked to a monitored station (preferably by the fire department). The location of the smoke detectors above the ceiling tiles and below the raised floor should be marked on the tiling for easy identification and access. Smoke detectors should supplement, not replace, fire suppression systems.

Fire Suppression Systems
These systems are designed to automatically activate immediately after detection of high heat, typically generated by fire. Like smoke detectors, the system should produce an audible alarm when activated and be linked to a central guard station that is regularly monitored. The system should also be inspected and tested annually. Testing intervals should comply with industry and insurance standards and guidelines. Ideally, the system should automatically trigger other mechanisms to localize the fire. This includes closing fire doors, notifying the fire department, closing off ventilation ducts and shutting down nonessential electrical equipment. In addition, the system should be segmented so a fire in one part of a large facility does not activate the entire system.

Broadly speaking, there are two methods for applying an extinguishing agent: total flooding and local application.

Systems working under *a total flooding* principle apply an extinguishing agent to a three-dimensional enclosed space in order to achieve a concentration of the agent (volume percent of the agent in air) adequate to extinguish the fire. These types of systems may be operated automatically by detection and related controls or manually by the operation of a system actuator.

Systems working under a *local application* principle apply an extinguishing agent directly onto a fire (usually a two-dimensional area), or into the three-dimensional region immediately surrounding the substance or object on fire. The main difference between local application and total flooding designs is the absence of physical barriers enclosing the fire space in the local application design.

In the context of automatic extinguishing systems, local application does normally not refer to the use of manually operated wheeled or portable fire extinguishers, although the nature of the agent delivery is similar.

The medium for fire suppression varies, but is usually one of the following:

- **Water-based systems** are typically referred to as sprinkler systems. These systems are effective but are also unpopular because they damage equipment and property. The system can be dry-pipe or charged (water is always in the system piping). A charged system is more reliable but has the disadvantage of exposing the facility to expensive water damage if the pipes leak or break.
- **Dry-pipe sprinkling systems** do not have water in the pipes until an electronic fire alarm activates the water pumps to send water into the system. This is opposed to a fully charged water pipe system. Dry-pipe systems have the advantage that a failure in the pipe will not result in water leaking into sensitive equipment from above. Because water and electricity do not mix, these systems must be combined with an automatic switch to shut down the electricity supply to the area protected.
- **Halon systems** release pressurized Halon gases that remove oxygen from the air, thus starving the fire. Halon was popular because it is an inert gas and does not damage equipment like water does. There should be an audible alarm and brief delay before discharge to permit personnel time to evacuate the area or to override and disconnect the system. Halon systems were prevalent for many years, but because Halon adversely affects the ozone layer, it was banned by the Montreal (Canada) Protocol of 1987. As a banned gas, all Halon installations are required by international agreements to be removed. Popular replacements are FM-200® and Argonite®.
- **FM-200®**—also called heptafluoropropane, HFC-227 or HFC-227ea (ISO name)—is a colorless odorless gaseous halocarbon, which is safe to be used where people are present. It is commonly used as a gaseous fire suppression agent. The HFC-227 fire suppression agent was the first nonozone-depleting replacement for Halon 1301. In addition, HFC-227 leaves no residue on valuable equipment after discharge. Trade names include FE-227™ (DuPont™), FM-200® (DuPont) and Solkaflam® 227 (Solvay Chemicals). This agent suppresses fire by discharging as a gas onto the surface of combusting materials. Large amounts of heat energy are absorbed from the surface of the burning material, lowering its temperature below the ignition point. FM-200 fire suppression systems have low atmospheric lifetimes, global warming and ozone depletion potentials.
- **Argonite®** is the brand name (a registered trademark owned by Ginge-Kerr) for a mixture of 50 percent argon (Ar) and 50 percent nitrogen (N2). It is an inert gas used in gaseous fire suppression systems for extinguishing fires where damage to equipment is to be avoided. Although argon is nontoxic, it does not satisfy the body's need for oxygen and is a simple asphyxiant. People have suffocated by breathing argon by mistake.

  Unlike carbon dioxide (CO_2) fire suppression systems, which are unable to sustain human life, FM-200 and Argonite systems are environmentally friendly. They provide an effective, safe method of fire suppression, and unlike charged sprinkler systems, they do not suffer from the disadvantage of exposing the expensive information processing facility (IPF) to water damage during the firefighting or if the pipe leaks or breaks.
- CO_2 systems release pressurized CO_2 gas into the area protected to replace the oxygen required for combustion. Unlike Halon and its later replacements, CO_2 is unable to sustain human life. Therefore, in most countries, it is illegal for such systems to be set to automatic release if any human may be in the area. Because of this, these systems are usually discharged manually, introducing an additional delay in combating the fire. CO_2 installations are permitted where no humans are regularly present, such as unmanned data centers (or "dark sites"), but there should be an automated facility for shutting down the system when anyone enters the area.

Strategically Locating the Computer Room
To reduce the risk of flooding, the computer room should not be located in the basement or top floor. If located in a multistory building, studies show that the best location for the computer room—the location which reduces the risk of fire, smoke and water damage—is on the middle floors (e.g., third, fourth, fifth or sixth floor). Adjacent water or gas pipes should be avoided except in the case of fire suppression systems. Care should be taken to avoid locating computer rooms adjacent to areas where functions carrying a high risk are carried out, such as paper storage. The activity of neighboring organizations should be considered when establishing a computer facility. Locations adjacent to, or on the final path to, an airport or a chemical works where explosive gases may be present, for example, should be avoided.

Where a data center is already located in an area vulnerable to flooding, such as a basement, an alternative to costly removal is the provision of a plastic sheet, or "umbrella," covering the area, which diverts any water flow away from the sensitive equipment.

Regular Inspection by Fire Department
To ensure that all fire detection systems comply with building codes, the fire department should inspect the system and facilities annually. Also, the fire department should be notified of the location of the computer room, so it can be prepared with equipment appropriate for electrical fires.

Fireproof Walls, Floors and Ceilings of the Computer Room
Walls surrounding the information processing facility should contain or block fire from spreading. The surrounding walls should be from true floor to the true ceiling and should have at least a two-hour fire resistance rating.

Electrical Surge Protectors

These electrical devices reduce the risk of damage to equipment due to power spikes. Voltage regulators measure the incoming electrical current and either increase or decrease the charge to ensure a consistent current. Such protectors are typically built into the UPS system.

Uninterruptible Power Supply/Generator
A UPS system consists of a battery or gasoline-powered generator that interfaces with the electrical power entering the facility and the electrical power entering the computer. The system typically cleanses the power to ensure that voltage into the computer is consistent. The UPS continues providing electrical power from the generator to the computer for a defined length of time should a power failure occur. Depending on the sophistication of the UPS, electrical power could continue to flow for days or for just a few minutes to permit an orderly computer shutdown. A UPS system can be built into a computer or can be an external piece of equipment.

Emergency Power-off Switch
There may be a need to immediately shut off power to the computer and peripheral devices such as during a computer room fire or emergency evacuation. Two emergency power-off switches should serve this purpose—one in the computer room, the other near, but outside, the computer room.

Switches should be clearly labeled and easily accessible, for this purpose, and yet they should still be secure from unauthorized people. The switches should be shielded to prevent accidental activation.

Power Leads From Two Substations
Electrical power lines that feed into the facility are exposed to many environmental hazards—water, fire, lightning, cutting due to careless digging, etc. To reduce the risk of a power failure due to these events that, for the most part, are beyond the control of the organization, redundant power lines should feed into the facility. In this way, interruption of one power line does not adversely affect electrical supply.

Fully Documented and Tested Business Continuity Plan
See section 2.12.10 Plan Testing for a description of testing BCPs.

Wiring Placed in Electrical Panels and Conduit
To reduce the risk of an electrical fire occurring and spreading, wiring should be placed in fire-resistant panels and conduit. This conduit generally lies under the fire-resistant raised computer room floor.

Inhibited Activities Within the Information Processing Facility
Food, drink and tobacco use can cause fires, the buildup of contaminants or damage to sensitive equipment (especially in the case of liquids). They should be prohibited from the information processing facility (IPF). This prohibition should be overt, such as with a sign on the entryway.

Fire-resistant Office Materials
Wastebaskets, curtains, desks, cabinets and other general office materials in the IPF should be fire-resistant. Cleaning fluids for desktops, console screens and other office furniture/fixtures should not be flammable.

Documented and Tested Emergency Evacuation Plans
Evacuation plans should emphasize human safety but should not leave IPFs physically unsecured. Procedures should be in place for a controlled shutdown of the computer in an emergency situation, if time permits.

5.7.3 AUDITING ENVIRONMENTAL CONTROLS

The following testing procedures should also be applied to any offsite storage and processing facilities. When this facility is outsourced to a third party, a contractual right of audit may be required. Assurance may also be provided through other methods, such as through Service Organization Control (SOC) reports.

Note that an IS auditor's first concern should be to establish the environmental risk by assessing the location of the data center. Higher risk items have a greater need for specific environmental controls.

Water and Smoke Detectors
Visual verification of the presence of water and smoke detectors in the computer room is needed. Whether the power supply to these detectors is sufficient should be determined, especially in instances of battery-operated devices. Also, the locations of the devices should be placed to give early warning of a fire, such as immediately above the computer equipment they are protecting, and should be clearly marked and visible.

Handheld Fire Extinguishers
Handheld fire extinguishers should be in strategic highly visible locations throughout the facility and should be inspected annually.

Fire Suppression Systems
Fire suppression systems are expensive to test and, therefore, the IS auditor's ability to determine operability is limited. IS auditors may need to limit their tests to reviewing documentation to ensure that the system has been inspected and tested within the last year. The exact testing interval should comply with industry and insurance standards and guidelines.

Regular Inspection by Fire Department
The person responsible for fire equipment maintenance should be contacted and asked if a local fire department inspector or insurance evaluator has been recently invited to tour and inspect the facilities. If so, a copy of the report should be obtained, and how to address the noted deficiencies should be determined.

Fireproof Walls, Floors and Ceilings of the Computer Room
With the assistance of building management, the documentation that identifies the fire rating of the walls surrounding the IPF should be located. These walls should have at least a two-hour fire resistance rating.

Electrical Surge Protectors
The presence of electrical surge protectors on sensitive and expensive computer equipment should be visually observed.

Power Leads From Two Substations
With the assistance of building management, documentation concerning the use and placement of redundant power lines into the IPF should be located.

Fully Documented and Tested Business Continuity Plan
See section 2.12.10 Plan Testing for a description of testing BCPs.

Wiring Placed in Electrical Panels and Conduit
Wiring in the IPF should be placed in fire-resistant panels and conduit.

UPS/Generator
The most recent test date should be determined and the test reports should be reviewed.

Documented and Tested Emergency Evacuation Plans
A copy of the emergency evacuation plan should be obtained. It should be examined to determine whether it describes how to leave the IPFs in an organized manner that does not leave the facilities physically insecure. A sample of IS employees should be interviewed to determine if they are familiar with the documented plan. The emergency evacuation plans should be posted throughout the facilities.

Humidity/Temperature Control
The IPF should be visited on regular intervals to determine whether temperature and humidity are adequate.

5.8 PHYSICAL ACCESS EXPOSURES AND CONTROLS

Physical exposures could result in financial loss, legal repercussions, loss of credibility or loss of competitive edge. They primarily originate from natural and man-made hazards, and can expose the business to unauthorized access and unavailability of the business information.

5.8.1 PHYSICAL ACCESS ISSUES AND EXPOSURES

Physical access issues are a major concern in security. Exposures and possible perpetrators are described in the following subsections.

Physical Access Exposures
Exposures that exist from accidental or intentional violation of these access paths include:
- Unauthorized entry
- Damage, vandalism or theft to equipment or documents
- Copying or viewing of sensitive or copyrighted information
- Alteration of sensitive equipment and information
- Public disclosure of sensitive information
- Abuse of data processing resources
- Blackmail
- Embezzlement

Possible Perpetrators
Possible perpetrators include employees with authorized or unauthorized access who are:
- Disgruntled (upset by or concerned about some action by the organization or its management)
- On strike
- Threatened by disciplinary action or dismissal
- Addicted to a substance or gambling
- Experiencing financial or emotional problems
- Notified of their termination

Other possible perpetrators could include:
- Former employees
- Interested or informed outsiders such as competitors, thieves, organized crime and hackers
- An accidental ignorant (e.g., someone who unknowingly perpetrates a violation)

The most likely source of exposure is from the uninformed, accidental or unknowing person, although the greatest impact may be from those with malicious or fraudulent intent.

Other questions and concerns to consider include the following:
- Are hardware facilities reasonably protected against forced entry?
- Are keys to the computer facilities adequately controlled to reduce the risk of unauthorized access?
- Are computer terminals locked or otherwise secured to prevent removal of boards, chips and the computer itself?
- Are authorized equipment passes required before computer equipment can be removed from its normal secure surroundings?

From an IS perspective, facilities to be protected include:
- Programming area
- Computer room
- Operator consoles and terminals
- Tape library, tapes, disks and all magnetic media
- Storage rooms and supplies
- Offsite backup file storage facility
- Input/output control room
- Communications closets
- Telecommunications equipment (including radios, satellites, wiring, modems and external network connections)
- Microcomputers and PCs

- Power sources
- Disposal sites
- Minicomputer establishments
- Dedicated telephones/telephone lines
- Control units and front-end processors
- Portable equipment (handheld scanners and coding devices, bar code readers, laptop computers, printers, pocket LAN adapters and others)
- Onsite and remote printers
- Local area networks

Additionally, system, infrastructure or software application documentation should be protected against unauthorized access.

For these safeguards to be effective, they must extend beyond the computer facility to include any vulnerable access points within the entire organization and at organizational boundaries/interfaces with external organizations. This may include remote locations and rented, leased or shared facilities. Additionally, the IS auditor may require assurances that similar controls exist within service providers or other third parties, if they are potentially vulnerable access points to sensitive information within the organization.

5.8.2 PHYSICAL ACCESS CONTROLS

Physical access controls are designed to protect the organization from unauthorized access. These controls should limit access to only those individuals authorized by management. This authorization may be explicit, as in a door lock for which management has authorized you to have a key, or implicit, as in a job description that implies a need to access sensitive reports and documents.

Bolting door locks require the traditional metal key to gain entry. The key should be stamped “do not duplicate” and should be stored and issued under strict management control.

Combination door locks (cipher locks) use a numeric key pad or dial to gain entry and are often seen at airport gate entry doors and smaller server rooms. The combination should be changed at regular intervals or whenever an employee with access is transferred, fired or subject to disciplinary action. This reduces the risk of the combination being known by unauthorized people.

Electronic door locks use a magnetic or embedded chip-based plastic card key or token entered into a sensor reader to gain access. A special code internally stored in the card or token is read by the sensor device that then activates the door locking mechanism. Electronic door locks have the following advantages over bolting and combination locks:
- Through the special internal code, cards can be assigned to an identifiable individual.
- Through the special internal code and sensor devices, access can be restricted based on the individual’s unique access needs. Restrictions can be assigned to particular doors or to particular hours of the day.
- They are difficult to duplicate.
- Card entry can be easily deactivated in the event an employee is terminated or a card is lost or stolen. Silent or audible alarms can be automatically activated if unauthorized entry is attempted. Issuing, accounting for and retrieving the card keys is an administrative process that should be carefully controlled. The card key is an important item to retrieve when an employee leaves the firm. An example of a common technique used for card entry is the swipe card. A swipe card is a physical control technique that uses a plastic card with a magnetic strip containing encoded data to provide access to restricted or secure locations. The encoded data can be read by a slotted electronic device. After a card has been swiped, the application attached to the slotted electronic device prevents unauthorized physical access to those sensitive locations, as well as logs all card users that try to gain access to the secure location.

Biometric door locks are activated by an individual’s unique body features, such as voice, retina, fingerprint, hand geometry or signature. This system is used in instances when extremely sensitive facilities must be protected such as in the military.

Manual logging means all visitors are required to sign a visitor’s log indicating their name, company representative, reason for visiting, person to see and date and time of entry and departure. Logging is typically done at the front reception desk and entrance to the computer room. Before gaining access, visitors should also be required to provide verification of identification such as a driver’s license, business card or vendor identification tag.

Electronic logging is a feature of electronic and biometric security systems. All access can be logged, with unsuccessful attempts being highlighted.

Identification badges (photo IDs) should be worn and displayed by all personnel. Visitor badges should be a different color from employee badges for easy identification. Sophisticated photo IDs can also be used as electronic card keys. Issuing, accounting for and retrieving the badges is an administrative process that must be carefully controlled.

Video (CCTV) cameras should be located at strategic points and monitored by security guards. Sophisticated video cameras can be activated by motion. The video surveillance recording should be retained for possible future playback, and it should be recorded in sufficient resolution to permit enlarging the image to identify an intruder.

Security guards are very useful if supplemented by video cameras and locked doors. Guards supplied by an external agency should be bonded to protect the organization from loss.

Controlled visitor access means all visitors should be escorted by a responsible employee. Visitors include friends, maintenance personnel, computer vendors, consultants (unless long-term, in which case special guest access may be provided) and external auditors.

All service contract personnel, such as cleaning people and offsite storage services, should be **bonded personnel**. This does not improve physical security but limits the financial exposure of the organization.

Deadman doors, also referred to as a mantrap or airlock entrance, uses two doors and is typically found in entries to facilities, such as computer rooms and high-security areas. For the second door to operate, the first entry door must close and lock, with only one person permitted in the holding area. This reduces the risk of piggybacking, when an unauthorized person follows an authorized person through a secured entry. In some installations, this same effect is accomplished through the use of a full height turnstile. Deadman doors may also be used for delivery and dispatch areas where outer doors open to admit

a truck and the inner doors cannot be opened to load or unload until the outer doors are closed and locked.

Computer workstation locks secure the device to the desk, prevent the computer from being turned on or disengage keyboard recognition, thus preventing use. Another available feature is locks that prevent turning on a PC workstation until a key lock is unlocked by a turnkey or card key. This is sometimes seen in the case of high-security workstations, such as those that process payroll.

A **controlled single entry point**, monitored by a receptionist, should be used by all incoming personnel. Multiple entry points increase the risk of unauthorized entry. Unnecessary or unused entry points, such as doors to outside smoking or break areas, should be eliminated. Emergency exits can be wired to an alarmed panic bar for quick evacuation.

An **alarm system** should be linked to inactive entry points, motion detectors, and the reverse flow of enter- or exit-only doors. Security personnel should be able to hear the alarm when activated.

Secured report/document distribution carts such as mail carts, should be covered and locked and should not be left unattended.

Facilities such as computer rooms should not be visible or identifiable from the outside; there should be no windows or directional signs. The building or department directory should discreetly identify only the general location of the information processing facility. If windows are present, they should be constructed of reinforced glass and, if on the ground floor of the building, further protected for example, by bars.

5.8.3 AUDITING PHYSICAL ACCESS

Touring the computer site is useful for the auditor to gain an overall understanding and perception of the installation being reviewed. As with environmental controls where the site is owned by a third party, a contractual right of audit may be required. This tour provides the opportunity to begin reviewing physical access restrictions (e.g., control over employees, visitors, intruders and vendors).

The computer site (i.e., computer room, developers' area, media storage, printer stations and management offices) and any offsite storage facilities should be included in this tour.

Much of the testing of physical safeguards can be achieved by visually observing the previously noted safeguards. Documents to assist with this effort include emergency evacuation procedures, inspection tags (recent inspection?), fire suppression system test results (successful? recently tested?) and key lock logs (all keys accounted for and not outstanding to former employees or consultants?).

Testing should extend beyond the computer room to include the following related facilities:
- Location of all operator consoles
- Printer rooms
- Computer storage rooms (this includes equipment, paper and supply rooms)
- UPS/generator
- Location of all communications equipment identified on the network diagram
- Media storage
- Offsite backup storage facility

To complete a thorough test, the IS auditor should look above the ceiling panels and below the raised floor in the computer operations center, observing smoke and water detectors, general cleanliness, and walls that extend all the way to the real ceiling (not just the fake/suspended ceiling). For a ground-floor computer room, the auditor may also consider walking around the outside of the room, viewing the location of any windows, examining emergency exit doors for evidence that they are routinely used (such as the presence of cigarette stubs or litter) and examining the air conditioning units. The auditor should also consider whether any additional threats exist close to the room, such as storage of dangerous or flammable material.

The following paths of physical entry should be evaluated for proper security:
- All entry doors
- Emergency exit doors
- Glass windows and walls
- Movable walls and modular cubicles
- Above suspended ceilings and beneath raised floors
- Ventilation systems
- Over a curtain, fake wall

5.9 MOBILE COMPUTING

Mobile computing refers to devices that are transported or moved during normal usage. Common mobiles devices include tablets, smartphones, laptops, USB storage devices, digital cameras and other similar technologies. Their mobility makes it more difficult to implement logical and physical access controls.

Figure 5.24 presents some known vulnerabilities and associated threats that need to be understood when dealing with mobile devices.

In addition, the advent of bring your own device (BYOD), where enterprises encourage staff to use their own mobile devices for company business, adds another layer of complexity when protecting these devices.
The following controls will reduce the risk of disclosure of sensitive data stored on mobile devices. Many of these can be enforced by mobile device management (MDM) systems and/or secure containers (a separately authenticated, encrypted area of the mobile device that is used to keep sensitive enterprise data segregated from the personal data) for both corporate and personal devices:
- **Device registration**—All mobile devices authorized for business use should be registered in a database. Devices that are personally owned should be flagged. Organizations can push updates or manage authorized devices and exclude personally owned mobile devices.
- **Tagging**—Physically tagging the device with an asset ID may result in its return should it be lost; however, there is risk in identifying the organization that owns the device.
- **Physical security**—If the device is stationary and permits it, use a cable locking system or a locking system with a motion detector that sounds an

audible alarm.

- **Data storage**—Only store what is absolutely needed on the device. With the ability to remotely access central servers the requirement to store any data locally should be questioned. If it is not stored locally, it will not be an issue if the device is lost or stolen. The data that are stored should be backed up on a regular basis, preferably to shared folders on the company's file server.
- **Virus detection and control**—The threat associated with viruses applies to all mobile devices. The enterprise should update the mobile device antivirus software to prevent perpetuation of malware.
- **Encryption**—Mobile devices used to store sensitive or confidential information should be encrypted in accordance with the organization's information security policies, mandating use of a strong encryption mechanism.
- **Compliance**—Mobile devices should comply with the security requirements as defined in corporate standards. All mobile devices should require a password. Two-factor authentication could be used to further enhance security.
- **Approval**—Mobile device use should be appropriately authorized and approved in accordance with the organization's policies and procedures.
- **Acceptable use policy**—A security policy should exist for mobile devices. The enterprise should have a policy addressing mobile device use and specifying the type of information and kind of devices and information services that may be accessible through the devices.

Figure 5.24—Mobile Device Vulnerabilities, Threats and Risk

Vulnerability	Threat	Risk
Information travels across wireless networks that are often less secure than wired networks.	Malicious outsiders can do harm to the enterprise.	Information interception resulting in a breach of sensitive data, enterprise reputation, adherence to regulation or legal action
Mobility provides users with the opportunity to leave enterprise boundaries and thereby eliminates many security controls.	Mobile devices cross boundaries and network perimeters, carrying malware, and can bring this malware into the enterprise network.	Malware propagation, which may result in data leakage, data corruption and unavailability of necessary data
Bluetooth technology is very convenient for many users to have hands-free conversations; however, it is often left on and then is discoverable.	Hackers can discover the device and launch an attack.	Device corruption, lost data, call interception, possible exposure of sensitive information
Unencrypted information is stored on the device.	In the event that a malicious outsider intercepts data in transit or steals a device or if the employee loses the device, the data are readable and usable.	Exposure of sensitive data, resulting in damage to the enterprise, customers or employees
Lost data may affect employee productivity.	Mobile devices may be lost or stolen due to their portability. Data on these devices are not always backed up.	Workers dependent on mobile devices unable to work in the event of broken, lost or stolen devices and data that are not backed up
The device has no authentication requirements applied.	In the event that the device is lost or stolen, outsiders can access the device and all of its data.	Data exposure, resulting in damage to the enterprise and liability and regulation issues
The enterprise is not managing the device.	If no mobile device strategy exists, employees may choose to bring in their own unsecured devices.	Data leakage, malware propagation or unknown data loss in the case of device loss or theft.
The device allows for installation of unsigned third-party applications.	Applications may carry malware that propagates Trojans or viruses; the applications may also transform the device into a gateway for malicious outsiders to enter the enterprise network.	Malware propagation, data leakage or intrusion on enterprise network

Source: ISACA, *Securing Mobile Devices*, USA, 2012

- **Due care**—Employees should exercise due care within office environments and especially during travel. Any loss or theft of a mobile device must be treated as a security breach and reported immediately in accordance to security management policies and procedures.
- **Awareness training**—Employee orientation and security awareness training should include coverage of mobile device policy and guidelines. The training will allow propagation of awareness that mobile devices are important business tools when used properly and have risk associated with them, if not managed accordingly.
- **Network authentication, authorization and accounting**—IT organizations should adopt a solution that allows them to tie devices connecting to the network with each user's identity and role and then apply role-based policies to grant proper access privileges. This enables IT to differentiate access for different levels of employees or guests or even by device type. It also lets IT take a proactive stance on tracking and monitoring how mobile devices are being used within their network.
- **Secure transmission**—Mobile devices should connect to the enterprise network via a secure connection, such as over a VPN.
- **Standard mobile device applications**—Configuration and use of the mobile device should be baselined and controlled. Only applications that either meet with the corporate security architecture or are delivered as standard on the mobile device should be authorized for use, and all software applications must be appropriately licensed and installed by the organization's IS support team. MDM solutions support this.
- **Geolocation tracking**—There are many debates about the privacy concerns of GPS tracking, but location capabilities inherent in mobile devices can be invaluable in the case of loss or theft.
- **Remote wipe and lock**—Due to the nature of mobile devices, many device management solutions are focused on securing the device if it is lost or stolen. Some MDM solutions allow IT to send an alarm to the device to help identify the location for a user, and if truly lost, IT can then remotely wipe and lock the device and/or container.
- **BYOD**—An employee BYOD agreement or acceptable use agreement (AUA) should require the employee to agree with the items in the policy before the device can be used for business purposes. It may also state that devices can be seized if necessary for a legal matter. An AUA ensures that maintaining security when using personal devices is a responsibility that is shared between both the user and IT. In addition, BYOD should be approved by executive management and be subject to oversight and monitoring.
- **Secure remote support**—Employees relying on personal devices to conduct work will often be out of the office. Having a secure way to support and fix these devices from a remote location is imperative to maintain employee satisfaction. Depending on device type, remote support solutions allow help desks to configure devices, chat, transfer files, and even remotely see and control the device. It is important to select a solution that supports a wide variety of devices and keeps all access and activity logs behind the company's firewall to ensure security.

5.10 PEER-TO-PEER COMPUTING

Peer-to-peer (P2P) computing is a distributed architecture where tasks or workloads are shared between peers. In P2P computing, there is no specific server to which one connects. For the most part, the connection is established between two peers—a connection between any two or more systems for a common interest. P2P networks are used almost exclusively for file sharing. Enterprises should strongly consider the risk against any perceived advantages before allowing access to P2P networks (**figure 5.25**).

Figure 5.25—Risk of Peer-to-peer Computing

Threats and Vulnerabilities	Risk	Controls
Introduction of viruses and malware to the organizational network	• Data leakage/theft • "Owned" systems (zombies) • System downtime • Resources required to clean systems	• Ensure that antivirus and anti-malware controls are installed on all systems and updated daily. • Block P2P traffic. • Prevent installation of P2P clients. • Establish or update policies and standards. • Develop and conduct awareness training and campaigns to inform employees of the risk involved with P2P computing.
Copyrighted content held on the enterprises network	• Regulatory sanctions and fines • Adverse legal actions • Licensing issues • Reputational damage	• Block P2P traffic. • Prevent installation of P2P clients. • Establish or update policies and standards. • Develop and conduct awareness training and campaigns to inform employees of the risk involved with P2P computing.
Excessive use of P2P in the workplace	• Network utilization issues • Productivity loss	• Restrict P2P usage. • Establish or update policies and standards. • Develop and conduct awareness training and campaigns to inform employees of the risk involved with P2P computing.
IP address exposure	• IP spoofing • Traffic sniffing • Other IP-based attacks	• Block P2P traffic. • Prevent installation of P2P clients. • Establish or update policies and standards. • Network address translation.

5.11 INSTANT MESSAGING

Instant messaging (IM) is a communications service that enables a user to chat in real time over a network on the Internet. It is a popular mechanism for collaborating and keeping in touch. One can connect with another user and chat with prompt acknowledgment and response, rather than sending numerous email messages. However, there is risk associated with IM **(figure 5.26)**.

5.12 SOCIAL MEDIA

Social media technology involves the creation and dissemination of content through social networks using the Internet. The differences between traditional and social media are defined by the level of interaction and interactivity available to the consumer. For example, a viewer can watch the news on television with no interactive feedback mechanisms, while social media tools allow consumers to comment, discuss and even distribute the news. Use of social media has created highly effective communication platforms where any user, virtually anywhere in the world, can freely create content and disseminate this information in real time to a global audience ranging in size from a handful to literally millions.

There are many types of social media tools: blogs (e.g., WordPress), image and video sharing sites (e.g., Flickr and YouTube), social networking (e.g., Facebook), and professional networking (e.g., LinkedIn). The common link among all forms of social media is that the content is supplied and managed by individual users who leverage the tools and platforms provided by social media sites.

Enterprises are using social media to increase brand recognition, sales, revenue and customer satisfaction; however, there is risk associated with its usage. These are divided into those enterprises with a corporate social media presence (**figure 5.27**) and those whose employees engage in social media (**figure 5.28**).

Figure 5.26—Risk of Instant Messaging

Threats and Vulnerabilities	Risk	Controls
Introduction of viruses and malware to the organizational network (especially through phishing)	• Data leakage/theft • "Owned" systems (zombies) • System downtime • Resources required to clean systems	• Ensure that antivirus and anti-malware controls are installed on all systems and updated daily. • Block IM traffic. • Only allow an enclosed corporate IM solution. • Establish or update policies and standards. • Develop and conduct awareness training and campaigns to inform employees of the risk involved with IM.
Eavesdropping	• Data leakage/theft	• Encrypt IM traffic. • Only allow an enclosed corporate IM solution. • Establish or update policies and standards. • Develop and conduct awareness training and campaigns to inform employees of the risk involved with IM.
Excessive use of IM in the workplace	• Network utilization issues • Productivity loss	• Restrict IM usage. • Establish or update policies and standards. • Develop and conduct awareness training and campaigns to inform employees of the risk involved with IM.

Figure 5.27—Risk of a Corporate Social Media Presence		
Threats and Vulnerabilities	**Risk**	**Controls**
Introduction of viruses and malware to the organizational network	• Data leakage/theft • "Owned" systems (zombies) • System downtime • Resources required to clean systems	• Ensure that antivirus and anti-malware controls are installed on all systems and updated daily. • Use content filtering technology to restrict or limit access to social media sites. • Ensure that appropriate controls are also installed on mobile devices such as smartphones. • Establish or update policies and standards. • Develop and conduct awareness training and campaigns to inform employees of the risk involved with using social media sites.
Exposure to customers and the enterprise through a fraudulent or hijacked corporate presence	• Customer backlash/adverse legal actions • Exposure of customer information • Reputational damage • Targeted phishing attacks on customers or employees	• Engage a brand protection firm that can scan the Internet and search out misuse of the enterprise brand. • Give periodic informational updates to customers to maintain awareness of potential fraud and to establish clear guidelines regarding what information should be posted as part of the enterprise social media presence.
Unclear or undefined content rights to information posted to social media sites	• Enterprise's loss of control/legal rights of information posted to the social media sites	• Ensure that legal and communications teams carefully review user agreements for social media sites that are being considered. • Establish clear policies that dictate to employees and customers what information should be posted as part of the enterprise social media presence. • If feasible and appropriate, ensure that there is a capability to capture and log all communications.
A move to a digital business model may increase customer service expectations.	• Customer dissatisfaction with the responsiveness received in this arena, leading to potential reputational damage for the enterprise and customer retention issues	• Ensure that staffing is adequate to handle the amount of traffic that could be created from a social media presence. • Create notices that provide clear windows for customer response.
Mismanagement of electronic communications that may be impacted by retention regulations or e-discovery	• Regulatory sanctions and fines • Adverse legal actions	• Establish appropriate policies, processes and technologies to ensure that communications via social media that may be impacted by litigation or regulations are tracked and archived appropriately. • Note that, depending on the social media site, maintaining an archive may not be a recommended approach.
Source: ISACA, *Social Media: Business Benefits and Security, Governance and Assurance Perspectives*, USA, 2010, figure 1		

Figure 5.28—Risk of Employee Personal Use of Social Media		
Threats and Vulnerabilities	**Risk**	**Controls**
Use of personal accounts to communicate work-related information	• Privacy violations • Reputational damage • Loss of competitive advantage	• Work with the human resources (HR) department to establish new policies or ensure that existing policies address employee posting of work-related information. • Work with the HR department to develop awareness training and campaigns that reinforce these policies.
Employee posting of pictures or information that link them to the enterprise	• Brand damage • Reputational damage	• Work with the HR department to develop a policy that specifies how employees may use enterprise related images, assets and intellectual property (IP) in their online presence.
Excessive employee use of social media in the workplace	• Network utilization issues • Productivity loss • Increased risk of exposure to viruses and malware due to longer duration of sessions	• Manage accessibility to social media sites through content filtering or by limiting network throughput to social media sites.
Employee access to social media via enterprise-supplied mobile devices (smartphones, tablets)	• Infection of mobile devices • Data theft from mobile devices • Circumvention of enterprise controls • Data leakage	• If possible, route enterprise smartphones through corporate network filtering technology to restrict or limit access to social media sites. • Ensure that appropriate controls are also installed and continuously updated on mobile devices such as smartphones. • Establish or update policies and standards regarding the use of smartphones to access social media. • Develop and conduct awareness training and campaigns to inform employees of the risk involved with using social media sites.
Source: ISACA, *Social Media: Business Benefits and Security, Governance and Assurance Perspectives*, USA, 2010, figure 2		

5.13 CLOUD COMPUTING

As discussed in section 2.9.2 Sourcing Practices, there are different service models (IaaS, PaaS, and SaaS) and deployment models (private cloud, community cloud, public cloud and hybrid cloud) available when considering cloud computing.

Regardless of the models deployed, the security objectives required to meet organization's business requirements must still be met. These include the following:

- Ensure the continued availability of their information systems and data.
- Ensure the integrity of the information stored on their computer systems and while in transit.
- Preserve the confidentiality of sensitive data while stored and in transit.
- Ensure conformity to applicable laws, regulations and standards.
- Ensure adherence to trust and obligation requirements in relation to any information relating to an identified or identifiable individual (i.e., data subject) in accordance with its privacy policy or applicable privacy laws and regulations.
- Ensure that sensitive data are adequately protected while stored and when in transit, based on organizational requirements.

Risk associated with cloud computing and associated controls is described in **figure 5.29**.

Figure 5.29—Risk Associated with Cloud Computing

Risk	Description	Control
Legal transborder requirements	Cloud service providers (CSPs) are often transborder, and different countries have different legal requirements, especially concerning personal private information. The enterprise might be committing a violation of regulations in other countries when storing, processing or transmitting data within the CSP's infrastructure without the necessary compliance controls. Furthermore, government entities in the hosting country may require access to the enterprise's information with or without proper notification.	• Request the CSP's list of infrastructure locations and verify that regulation in those locations is aligned with the enterprise's requirements. • Include terms in the contract to restrict the moving of enterprise assets to only those areas known to be compliant with the enterprise's own regulation. • Prevent disclosure, encrypt any asset prior to migration to the CSP and ensure proper key management is in place.
Physical security	Physical security is required in any infrastructure. When the enterprise moves assets to a cloud infrastructure, those assets are still subject to the corporate security policy, but they can also be physically accessed by the CSP's staff, which is subject to the CSP's security policy. There could be a gap between the security measures provided by the CSP and the requirements of the enterprise.	• Request the CSP's physical security policy and ensure that it is aligned with the enterprise's security policy. • Request that the CSP provide proof of independent security reviews or certification reports that meet the enterprise's compliance requirements (e.g., SOC reports, SOX, PCI DSS, HIPAA, ISO certification). • Include in the contract language that requires the CSP to be aligned with the enterprise's security policy and to implement necessary controls to ensure it. • Request the CSP's disaster recovery plans and ensure that they contain the necessary countermeasures to protect physical assets during and after a disaster.
Data disposal	Proper disposal of data is imperative to prevent unauthorized disclosure. If appropriate measures are not taken by the CSP, information assets could be sent (without approval) to countries where the data can be legally disclosed due to different regulations concerning sensitive data. Disks could be replaced, recycled or upgraded without proper cleaning so that the information still remains within storage and can later be retrieved. When a contract expires, CSPs should ensure the safe disposal or destruction of any previous backups. Any of the data fed into the CSP's application must be erased immediately using the necessary tools to avoid disclosures and confidentiality breaches (forensic cleaning may be required for sensitive data).	• Request CSP's technical specifications and controls that ensure that data are properly wiped and backup media are destroyed when requested. • Include terms in the contract that require, upon contract expiration or any event ending the contract, a mandatory data wipe carried out under the enterprise's supervision.
Multi-tenancy and isolation failure	One of the primary benefits of the cloud is the ability to perform dynamic allocation of physical resources when required. The most common approach is a multi-tenant environment (public cloud), where different entities share a pool of resources, including storage, hardware and network components. For example, when allocated storage is no longer needed by a client it can be freely reallocated to another enterprise. In that case, sensitive data could be disclosed if the storage has not been scrubbed thoroughly (e.g., using forensic software). Furthermore, malicious entities in the cloud could take advantage of shared information—for example, by utilizing shared routing tables to map the internal network topology of an enterprise, preparing the way for an internal attack.	• Request the CSP's technical details for approval and require additional controls to ensure data privacy, when necessary. • A contractual agreement is necessary to officially clarify who is allowed to access the enterprise's information, naming specific roles for CSP employees and external partners. All controls protecting the enterprise's information assets must be clearly documented in the contract agreement or service level agreement (SLA). • Use a private cloud deployment model (no multi-tenancy).
Application disposal	When applications are developed in a PaaS environment, originals and backups should always be available. In the event of a contract termination, the details of the application could be disclosed and used to create more selective attacks on applications or could be copied violating the enterprise's IP.	• Include terms in the contract that require the proper disposal of applications including objects, source and backups. • Include non-compete clauses in the contract.
Lack of visibility into software systems development life cycle (SDLC)	Enterprises that use cloud applications have little visibility into the software SDLC. Customers do not know in detail how the applications were developed and what security considerations were taken into account during the SDLC. This could lead to an imbalance between the security provided by the application and the security required by customers/users.	• If possible include a right of audit in the contract. • Include in the contract language that requires the CSP to be aligned with the enterprise's security policy and to implement necessary controls to ensure it. • Require SLAs that include a schedule of software changes.
Lack of control of the release management process	CSPs are able to introduce patches in their applications	• If possible, include a right of audit in the contract.

	quickly. These deployments are often done without the approval (or even the knowledge) of the application users for practical reasons: if an application is used by hundreds of different enterprises, it would take an extremely long time for a CSP to look for the formal approval of every customer. In this case, the enterprise could have no control (or no view) of the release management process and could be subject to unexpected side effects.	• Include in the contract language that requires the CSP to be aligned with the enterprise's security policy and to implement necessary controls to ensure it. • Require SLAs that include a schedule of patches and software releases.
Identity and access management (IAM)	Information assets could be accessed by unauthorized entities due to faulty or vulnerable access management measures or processes. This could result from a forgery/theft of legitimate credentials or a common technical practice (e.g., administrator permissions override).	• If possible, include a right of audit in the contract. • Include in the contract language that requires the CSP to be aligned with the enterprise's security policy and to implement necessary controls to ensure it. • Request that the CSP provide proof of independent security reviews or certification reports that meet the enterprise's compliance requirements (e.g., SOC reports, SOX, PCI DSS, HIPAA, ISO certification).
Service Orientated Architecture (SOA)–related vulnerabilities	Security for SOA presents new challenges because vulnerabilities arise not only from the individual elements, but also from their mutual interaction. Because the SOA libraries are under the responsibility of the CSP and are not completely visible to the enterprise, there may be unnoticed application vulnerabilities.	• If possible include a right of audit in the contract. • Include in the contract language that requires the CSP to be aligned with the enterprise's security policy and to implement necessary controls to ensure it. • Request that the CSP provide proof of independent security reviews or certification reports that meet the enterprise's compliance requirements (e.g., SOC reports, SOX, PCI DSS, HIPAA, ISO certification).
Exit strategy	CSPs tools facilitate bring data to the cloud or CSP but rarely the other way around. This can make it very difficult for the enterprise to migrate from one CSP to another or to bring services back in-house. It can also result in serious business disruption or failure should the CSP go bankrupt, face legal action or be the potential target for an acquisition (with the likelihood of sudden changes in CSP policies and any agreements in place). If the organization decides to bring the data back in-house, the question of how to securely render the data becomes critical because the in-house applications may have been decommissioned or "sunsetted" and there is no application available to render the data. Another possibility is the "run on the banks" scenario, in which there is a crisis of confidence in the CSP's financial position resulting in a mass exit and withdrawal on first-come, first-served basis. If there are limits to the amount of content that can be withdrawn in a given time frame, then the enterprise might not be able to retrieve all its data in the time specified.	• Ensure by contract or SLA with the CSP an exit strategy that specifies the terms that should trigger the retrieval of the enterprise's assets in the time frame required by the enterprise. • Implement a disaster recovery plan, taking into account the possibility of complete CSP disruption.
Ease to contract SaaS	Business organizations may contract cloud applications without proper procurement and approval oversight, thus bypassing compliance with internal enterprise policies.	• Require that the purchase of cloud services follow the established procedures. Ensure executive management support for this.
Collateral damage	If one tenant of a public cloud is attacked, there could be an impact to the other tenants of the same CSP, even if they are not the intended target (e.g., DDoS). Another possible scenario of collateral damage could be a public cloud IaaS that is affected by an attack exploiting vulnerabilities of software installed by one of the tenants.	• Ask the CSP to include the enterprise in its incident management process that deals with notification of collateral events. • Include contract clauses and controls to ensure that the enterprise's contracted capacity is always available and cannot be directed to other tenants without approval. • Use a private cloud deployment model (no multi-tenancy).
Hypervisor attacks	Hypervisors are vital for server virtualization. They provide the link between virtual machines and the underlying physical resources required to run the machines by using hypercalls (similar to system calls, but for virtualized systems). An attacker using a virtual machine in the same cloud could fake hypercalls to inject malicious code or trigger bugs in the hypervisor. This could potentially be used to violate confidentiality or integrity of other virtual machines or crash the hypervisor (similar to a DDoS attack).	• If possible include a right of audit in the contract. • Include in the contract language that requires the CSP to be aligned with the enterprise's security policy and to implement necessary controls to ensure it.
Support for audit and forensic investigations	Security audits and forensic investigations are vital to the enterprise to evaluate the security measures of the CSP (preventive and corrective), and in some cases the CSP itself (for example, to authenticate the CSP). This raises several issues because performing these actions requires extensive access to the CSP's infrastructure and monitoring capabilities, which are often shared with other CSP's customers.	• Request the CSP the right to audit as part of the contract or SLA. If this is not possible, request security audit reports by trusted third parties. • Request that the CSP provide appropriate and timely support (logs, traces, hard disk images, etc.) for forensic analysis as part of the contract or SLA. If this is not possible, request to authorize trusted third parties to perform forensic analysis when necessary.

Source: Data from ISACA; *Security Considerations for Cloud Computing*, USA, 2012.

5.14 DATA LEAKAGE

As previously discussed, data leakage involves siphoning or leaking information out of the computer. This includes dumping files to paper or stealing computer reports and tapes. Unlike product leakage, data leakage leaves the original copy, so it may go undetected.

Fundamentally, data leakage involves the unauthorized transfer of sensitive or proprietary information from an internal network to the outside world.

Ways that this information can leave the enterprise include P2P networks, IM, social media, email, cloud storage and file sharing solutions.

Common controls to prevent data leakage have also been covered including identifying assets, classifying them and an ISMS, including policies and procedures.

Despite these controls, many enterprises still leak sensitive information. These leaks create risk to enterprises, their customers and business partners negatively impact an enterprise's reputation, compliance, competitive advantage and finances.

Concerns over the need to better control and protect sensitive information have given rise to a new set of solutions. These solutions vary in their capabilities and methodologies, but collectively they have been placed in a category known as data leak prevention (or protection).

5.14.1 DATA LEAK PREVENTION

Data leak prevention (DLP) is suite of technologies and associated processes that locate, monitor and protect sensitive information from unauthorized disclosure. Most DLP solutions include a suite of technologies that facilitates three key objectives:

- Locate and catalog sensitive information stored throughout the enterprise.
- Monitor and control the movement of sensitive information across enterprise networks.
- Monitor and control the movement of sensitive information on end-user systems.

These objectives are associated with three primary states of information: data at rest, data in motion and data in use. Each of these three states of data is addressed by a specific set of technologies provided by DLP solutions.

Data at Rest

A basic function of DLP solutions is the ability to identify and log where specific types of information (e.g., credit card or social security numbers) are stored throughout the enterprise. To accomplish this, most DLP systems use crawlers, which are applications that are deployed remotely to log onto each end system and "crawl" through data stores, searching for and logging the location of specific information sets based on a set of rules that have been entered into the DLP management console.

Data in Motion (Network)

To monitor data movement on enterprise networks, DLP solutions use specific network appliances or embedded technology to selectively capture and analyze network traffic. When files are sent across a network they are typically broken into packets. To inspect the information being sent across the network the DLP solution must be able to passively monitor the network traffic, recognize the correct data streams to capture, assemble the collected packets, reconstruct the files carried in the data stream, and perform the same analysis that is done on the data at rest to determine whether any portion of the file contents is restricted by its rule set. At the core of this ability is a process known as deep packet inspection (DPI). DPI goes beyond the basic header information of a packet to read the contents within the packet's payload (akin to a letter within a postal envelope). If sensitive data are detected flowing to an unauthorized destination, the DLP solution has the capability to alert and optionally block the data flows in real or near real time, again based on the rule set defined within its central management component. Based on the rule set, the solution may also quarantine or encrypt the data in question.

Data in Use (Endpoint)

Data in use primarily refers to monitoring data movement stemming from actions taken by end users on their workstations, whether that would entail copying data to a flash drive, sending information to a printer or even cutting and pasting between applications. DLP solutions typically accomplish this through the use of a software program known as an agent, which is ideally controlled by the same central management capabilities of the overall DLP solution.

To be considered a full DLP solution, the capability to address the three states of information must exist and be integrated by a centralized management function. The range of services available in the management console varies between products but many have functions in common, such as those outlined in the following sections.

Policy Creation and Management

Policies (rule sets) dictate the actions taken by the various DLP components. Most DLP solutions come with preconfigured policies (rules) that map to common regulations. It is just as important to be able to customize these policies or build completely custom policies. These should be built upon the asset management and data classifications exercises performed by the enterprise.

Directory Services Integration

Integration with directory services allows the DLP console to map a network address to a named end user.

Workflow Management

Most full DLP solutions provide the capacity to configure incident handling, allowing the central management system to route specific incidents to the appropriate parties based on violation type, severity, user and other such criteria.

Backup and Restore

Backup and restore features allow for preservation of policies and other configuration settings.

Reporting

A reporting function may be internal or may leverage external reporting tools.

5.14.2 DLP RISK, LIMITATIONS AND CONSIDERATIONS

- **Improperly tuned network DLP modules**—Proper tuning and testing of the DLP system should occur before enabling actual blocking of content. Enabling the system in monitor-only mode will allow for tuning and provide the opportunity to alert users to out-of-compliance processes and activities, so they may make adjustments accordingly. Involving the appropriate business and IT stakeholders in the planning and monitoring stages will help ensure that disruptions to processes will be anticipated and mitigated. Finally, establish some means of accessibility in the event there is critical content being blocked during off-hours when the team managing the DLP solution is not available.

- **Excessive reporting and false positives**—Similar to an improperly configured IDS, DLP solutions may register significant amounts of false positives, which overwhelm staff and can obscure valid hits. Avoid excessive use of template patterns or "black box" solutions that allow for little customization. The greatest feature of a DLP solution is the ability to customize rules or templates to specific organizational data patterns. It is also important that the system be rolled out in phases, focusing on the highest risk areas first. Trying to monitor too many data patterns or enabling too many detection points early on can quickly overwhelm resources.
- **Encryption**—DLP solutions can only inspect encrypted information that they can first decrypt. To do this, DLP agents, network appliances and crawlers must have access to, and be able to utilize, the appropriate decryption keys. If users have the ability to use personal encryption packages where keys are not managed by the enterprise and provided to the DLP solution, the files cannot be analyzed. To mitigate this risk, policies should forbid the installation and use of encryption solutions that are not centrally managed, and users should be educated that anything that cannot be decrypted for inspection (meaning that the DLP solution has the encryption key) will ultimately be blocked.
- **Graphics**—DLP solutions cannot intelligently interpret graphics files. Short of blocking or manually inspecting all such information, a significant gap will exist in an enterprise's control of its information. Sensitive information scanned into a graphics file or intellectual property that exists in a graphics format, such as design documents, would fall into this category. Enterprises that have significant intellectual property in a graphics format should develop strong policies that govern the use and dissemination of this information. While DLP solutions cannot intelligently read the contents of a graphics file, they can identify specific file types, their source and destination. This capability, combined with well-defined traffic analysis, can flag uncharacteristic movement of this type of information and provide some level of control.

5.15 END-USER COMPUTING SECURITY RISK AND CONTROLS

As noted in chapter 4, end-user computing (EUC) refers to the ability of end users to design and implement their own information system utilizing computer software products. Notwithstanding the aforementioned benefits the lack of IT department oversight can lead to security risk. Examples include:
- **Authorization**—There may be no secure mechanism to authorize access to the system
- **Authentication**—There may be no secure mechanism to authenticate users to the system
- **Audit logging**—This is not available on standard EUC solutions (e.g. Microsoft Excel, Access, etc.)
- **Encryption**—The application may contain sensitive data which has not been encrypted or otherwise protected

The IS auditor should ensure that policies for the use of EUC exist. According to chapter 4 IT Asset Management, an inventory of all such applications should exist. In most instances EUC applications will not pose a significant risk to the enterprise. Nonetheless, management should define risk criteria to determine the criticality of the application. These should also be subject to data classification with those deemed critical enough subject to the same controls as any other application.

5.16 CASE STUDIES

The following case studies are included as a learning tool to reinforce the concepts introduced in this chapter.

5.16.1 CASE STUDY A

Management is currently considering ways in which to enhance the physical security and protection of its data center. The IS auditor has been asked to assist in this process by evaluating the current environment and making recommendations for improvement. The data center consists of 15,000 square feet (1,395 square meters) of raised flooring on the ground floor of the corporate headquarters building. A total of 22 operations personnel require regular access. Currently, access to the data center is obtained using a proximity card, which is assigned to each authorized individual. There are three entrances to the data center, each of which utilizes a card reader and has a camera monitoring the entrance. These cameras feed their signals to a monitor at the building reception desk, which cycles through these images along with views from other cameras inside and outside the building. Two of the doors to the data center also have key locks that bypass the electronic system so that a proximity card is not required for entry. Use of proximity cards is written to an electronic log. This log is retained for 45 days. During the review, the IS auditor noted that 64 proximity cards are currently active and issued to various personnel. The data center has no exterior windows, although one wall is glass and overlooks the entry foyer and reception area for the building.

Case Study A Questions	
A1.	Which of the following risk would be mitigated by supplementing the proximity card system with a biometric scanner to provide two-factor authentication? A. Piggybacking or tailgating B. Sharing access cards C. Failure to log access D. Copying of keys
A2.	Which of the following access mechanisms would present the greatest difficulty in terms of user acceptance? A. Hand geometry recognition B. Fingerprints C. Retina scanning D. Voice recognition
See answers and explanations to the case study questions at the end of the chapter (page 414).	

5.16.2 CASE STUDY B

A company needed to enable remote access to one of its servers for remote maintenance purposes. Firewall policy did not allow any external access to the internal systems. Therefore, it was decided to install a modem on that server and to activate the remote access service to permit dial-up access. As a control, a policy has been implemented to manually power on the modem only when the third party was requesting access to the server and powered off by the company's system administrator when the access is no longer needed. As more and more systems are being maintained remotely, the company is asking an IS auditor to evaluate the current risk of the existing solution and to propose the best strategy for addressing future connectivity requirements.

Case Study B Questions	

B1.	What test is **MOST** important for the IS auditor to perform as part of the review of dial-up access controls? A. Dial the server from authorized and unauthorized telephone lines B. Determine bandwidth requirements of remote maintenance and the maximum line capacity C. Check if the availability of the line is guaranteed to allow remote access any time D. Check if call back is not used and the cost of calls is charged to the third party
B2.	What is the **MOST** significant risk that the IS auditor should evaluate regarding the existing remote access practice? A. Modem is not powered on/off whenever is needed B. A nondisclosure agreement was not signed by the third party C. Data exchanged over the line is not encrypted D. Firewall controls are bypassed
B3.	Which of the following recommendations is **MOST** likely to reduce the current level of remote access risk? A. Maintain an access log with the date and time when the modem was powered on/off B. Encrypt the traffic over the telephone line C. Migrate the dial-up access to an Internet VPN solution D. Update firewall policies and implement an IDS system
B4.	What control should be implemented to prevent an attack on the internal network being initiated though an Internet VPN connection? A. Firewall rules are periodically reviewed B. All VPNs terminate at a single concentrator C. An IDS capable to analyze encrypted traffic is implemented D. Antivirus software is installed on all production servers
See answers and explanations to the case study questions at the end of the chapter (page 414).	

5.16.3 CASE STUDY C

"My Music" is a company dedicated to the production and distribution of video clips specializing in jazz music. Born in the Internet era, the company has actively supported the use of laptops computers by its staff so they can use them when traveling and when working from home. Through the Internet they can access the company databases and provide online information to customers. This decision has resulted in an increase in productivity and high morale among employees who are allowed to work up to two days a week from home. Based on written procedures and a training course, employees learn security procedures to avoid the risk of unauthorized access to company data. Employees' access to the company data includes using logon IDs and passwords to the application server through a VPN. Initial passwords are assigned by the security administrator. When the employee logs on for the first time, the system forces a password change to improve confidentiality.

Management is currently considering ways to improve security protection for remote access by employees. The IS auditor has been asked to assist in this process by evaluating the current environment and making recommendations for improvement.

Case Study C Questions	
C1.	Which of the following levels provides a higher degree of protection in applying access control software to avoid unauthorized access risk? A. Network and OS level B. Application level C. Database level D. Log file level
C2.	When an employee notifies the company that he/she has forgotten his/her password, what should be done **FIRST** by the security administrator? A. Allow the system to randomly generate a new password B. Verify the user's identification through a challenge/response system C. Provide the employee with the default password and explain that it should be changed as soon as possible D. Ask the employee to move to the administrator terminal to generate a new password in order to assure confidentiality
See answers and explanations to the case study questions at the end of the chapter (page 415).	

5.16.4 CASE STUDY D

A major financial institution has just implemented a centralized banking solution (CBS) in one of its branches. It has a secondary concern to look after marketing of the bank. Employees of a separate legal entity work on the bank premises, but they have no access to the bank's solution software. Employees of other branches get training on this solution from this branch and for training purposes temporary access credentials are also given to such employees. IS auditors observed that employees of the separate legal entity also access the CBS software through the branch employees access credentials. IS auditors also observed that there are numerous active IDs of employees who got training from the branch and have since been transferred to their original branch.

Case Study D Questions	
D1.	Which of the following should IS auditors recommend to effectively eliminate such password sharing? A. Assimilation of security need to keep password secret B. Stringent rules prohibiting sharing of password C. Use of smart card along with strong password D. Use of smart card along with employee's terminal ID
D2.	Which of the following **BEST** addresses user ID management of trainee employees? A. Unused user ID shall be automatically deleted periodically B. To integrate access rights with human resource process C. Password of unused but active user ID shall be suspended D. Active user ID register shall checked frequently

See answers and explanations to the case study questions at the end of the chapter (page 415).

5.17 ANSWERS TO CASE STUDY QUESTIONS

ANSWERS TO CASE STUDY A QUESTIONS

A1. **B** Two-factor authentication involving the use of biometrics would effectively prevent the sharing of access cards because these cards would be ineffective without the corresponding biometric. Piggybacking or tailgating would not be mitigated because traffic flow would remain unchanged. Because two entrances utilize key locks that override the electronic entry system, individuals entering using keys would not be logged by the electronic system, and keys could still potentially be copied.

A2. **C** Although the highest in terms of accuracy, many individuals feel uncomfortable with the idea of having a device scan the inside of their eye. So, even though retina scanning may be highest in terms of effectiveness from a control perspective, its lack of user acceptance may make it inappropriate for applications where customer acceptance is of prime importance. Fingerprints, hand geometry and voice recognition are all less invasive and, therefore, not as subject to adverse negative reaction by users. The objective of this area is to ensure that the CISA candidate understands and can provide assurance that the security architecture (policies, standards, procedures and controls) ensures the confidentiality, integrity and availability of information assets.

ANSWERS TO CASE STUDY B QUESTIONS

B1. **A** Dial-up access should be possible only from authorized telephone lines as a preventive control for unauthorized access when logon credentials are compromised or misused by third-party personnel. Initiating the connection by the server to an authorized phone number using the call back feature would be one implementation of this requirement. Options B, C and D address performance issues and not access control issues.

B2. **D** The company's security infrastructure relies on controls implemented on the firewall. The fact that someone from the outside can connect directly to an internal system, bypassing firewall rules, could expose the internal network to the third party, thereby facilitating unauthorized access. Choices A, B and C are types of risk to be considered by the IS auditor, but concern only the server being maintained remotely, and not the entire internal system.

B3. **C** Using an Internet VPN solution will eliminate the vulnerabilities of the dial-up access such as lack of encryption and bypassing firewall controls. Option A and B will address punctual issues and Option D will have no effect since security infrastructure controls are bypassed by the direct dial-up access.

B4. **C** An IDS should be able to analyze the encrypted traffic of the VPN connection to determine potential attacks. A firewall rules review and ending all VPNs in a single concentrator will prevent unauthorized connections to the internal network, but this will not prevent an attack occurring through an authorized VPN connection. Antivirus software will prevent contamination by computer viruses, but the internal system is still vulnerable to many other threats.

ANSWERS TO CASE STUDY C QUESTIONS

C1. **A** The greatest degree of protection in applying access control software against internal and external users' unauthorized access is at the network and platform/OS levels. These systems are also referred to as general support systems, and they make up the primary infrastructure on which applications and database systems will reside.

C2. **B** When an employee notifies that he/she has forgotten his/her password, the security administrator should start a password process generation procedure only after verifying the user's identification using a challenge/response system or similar procedure. To verify, it is advised that the security administrator should return the user's call after verifying his/her extension or calling his/her supervisor for verification.

ANSWERS TO CASE STUDY D QUESTIONS

D1. **A** Assimilation of security need to keep password secret can only effectively refrain such password sharing and such assimilation is possible only through continuous and conscientious security awareness and education programs. Without assimilation of security need stringent rules prohibiting sharing of password cannot effectively stop password sharing. Use of smart card along with strong password and use of smart card along with employee's terminal ID do not deter password sharing.

D2. **B** Integration of access rights with human resource process is the best way to address user ID management. Automatic periodic deletion of unused user ID, suspension of password of unused but active user ID and frequently checking active user ID register are not the best way since vulnerability persists during the period in which user IDs remain active.