SOLUTIONS MANUAL

COMPUTER SECURITY
FOURTH EDITION
GLOBAL EDITION

CHAPTERS 13–25

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NOTICE

This manual contains solutions to the review questions and homework problems in *Computer Security, Fourth Edition, Global Edition*. If you spot an error in a solution or in the wording of a problem, I would greatly appreciate it if you would forward the information via email to wllmst@me.net. An errata sheet for this manual, if needed, is available at http://www.box.net/shared/ds8lygu0tjljokf98k85 . File name is S-CompSec4e-mmyy.

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CHAPTER 13 CLOUD AND IOT SECURITY

ANSWERS TO QUESTIONS

13.1 Followings are the essential characteristics of cloud computing:

1. Broad network access
2. Measured service
3. On-demand self-service
4. Rapid elasticity
5. Resource pooling

13.2 **Software as a service (SaaS)**: Provides service to customers in the form of software, specifically application software, running on and accessible in the cloud.
Platform as a service (PaaS): Provides service to customers in the form of a platform on which the customer's applications can run.
Infrastructure as a service (IaaS): Provides the customer access to the underlying cloud infrastructure.

13.3 Following are the four most prominent deployment models for cloud security:

1. **Public Cloud:** A public cloud infrastructure is made available to the general public. The cloud provider is responsible both for the cloud infrastructure and for the control of data and operations within the cloud. A public cloud may be owned, managed, and operated by a business, academic, or government organization, or some combination of them.
2. **Private Cloud:** A private cloud is implemented internally within organization. The organization may choose to manage the cloud in house or contract the management function to a third party.
3. **Community Cloud:** A community cloud has characteristics of both private and public clouds. Similar to a private cloud, a community cloud has restricted access. Like a public cloud, the cloud resources are shared among a number of independent organizations. The organizations that share the community cloud have similar requirements and, typically, a need to exchange data with each other.
4. **Hybrid Cloud:** The hybrid cloud infrastructure is a composition of any two or more clouds (private, community, or public). For a hybrid cloud solution, sensitive information can be placed in a

private area of the cloud, and less sensitive data can take advantage of the benefits of the public cloud. A hybrid cloud solution can be particularly attractive for smaller businesses.

13.4 Abuse and nefarious use of cloud computing: For many CPs, it is relatively easy to register and begin using cloud services, some even offering free limited trial periods. This enables attackers to get inside the cloud to conduct various attacks, such as spamming, malicious code attacks, and denial of service.

Insecure interfaces and APIs: CPs expose a set of software interfaces or APIs that customers use to manage and interact with cloud services. The security and availability of general cloud services is dependent upon the security of these basic APIs. From authentication and access control to encryption and activity monitoring, these interfaces must be designed to protect against both accidental and malicious attempts to circumvent policy.

Malicious insiders: Under the cloud computing paradigm, an organization relinquishes direct control over many aspects of security and, in doing so, confers an unprecedented level of trust onto the CP. One grave concern is the risk of malicious insider activity. Cloud architectures necessitate certain roles that are extremely high-risk.

Shared technology issues: IaaS vendors deliver their services in a scalable way by sharing infrastructure. Often, the underlying components that make up this infrastructure (CPU caches, GPUs, etc.) were not designed to offer strong isolation properties for a multi-tenant architecture. CPs typically approach this risk by the use of isolated virtual machines for individual clients. This approach is still vulnerable to attack, by both insiders and outsiders, and so can only be a part of an overall security strategy.

Data loss or leakage: For many clients, the most devastating impact from a security breach is the loss or leakage of data. We address this issue in the next section.

Account or service hijacking: Account and service hijacking, usually with stolen credentials, remains a top threat. With stolen credentials, attackers can often access critical areas of deployed cloud computing services, allowing them to compromise the confidentiality, integrity, and availability of those services.

Unknown risk profile: In using cloud infrastructures, the client necessarily cedes control to the cloud provider on a number of issues that may affect security. Thus the client must pay attention to and clearly define the roles and responsibilities involved for managing risks. For example, employees may deploy applications and data resources at the CP without observing the normal policies and procedures for privacy, security, and oversight.

13.5 OpenStack is an open source software project of the OpenStack Foundation that aims to produce an open source cloud operating system.

13.6 The Internet of things (IoT) is a term that refers to the expanding interconnection of smart devices, ranging from appliances to tiny sensors

13.7 Followings are the five security requirements included in ITU-T:

1. Communication security.
2. Service provision security.
3. Integration of security policies and techniques.
4. Data management security.
5. Security audit.

13.8 The billions of IoT devices have various security vulnerabilities and there is no effective way to patch these in a timely manner.

13.9 Cisco has developed a framework for IoT security that serves as a useful guide to the security requirements for IoT.

13.10 The encryption algorithm Skipjack was developed in the 1990s by the U.S. National Security Agency (NSA). It is the best candidate among eight possible candidate algorithms for wireless security networks [LAW06]. This study concluded that Skipjack was the best algorithm in terms of encryption/decryption efficiency and data efficiency, which is critical to embedded systems. With its efficient computation and low memory footprint, Skipjack is an attractive choice for IoT devices.

CHAPTER 14 IT SECURITY MANAGEMENT AND RISK ASSESSMENT

ANSWERS TO QUESTIONS

14.1 The main functions of IT security management include:

- determining organizational IT security objectives, strategies, and policies
- determining organizational IT security requirements
- identifying and analyzing security threats to IT assets within the organization
- identifying and analyzing risks
- specifying appropriate safeguards
- monitoring the implementation and operation of safeguards that are necessary in order to cost effectively protect the information and services within the organization
- developing and implementing a security awareness program
- detecting and reacting to incidents

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14.3 The do step of Plan-Do-Check-Act model focuses on implementing the risk treatment plan whereas act step of Plan-Do-Check-Act model focuses on maintaining and improving the information security risk management process in response to incidents, review, or identified changes.

14.4 Key national and international standards that provide guidance on IT security management and risk assessment include: the ISO27000 series including ISO27001, ISO27002 (previously ISO17799), & ISO27005; ISO31000; ISO13335; NIST Special Publications including SP800-30 & SP800-53.

14.5 Based on the organizational security objectives and strategies, an organizational security policy describes what the objectives and strategies are and the process used to achieve them. Few key points, that such a policy must address, are:

- The scope and purpose of the policy.
- The risk management approach adopted by the organization
- How security awareness and training is to be handled
- Contingency and business continuity planning
- Incident detection and handling processes
- How and when this policy should be reviewed
- The method for controlling changes to this policy

14.6 An organizational security policy must address the following:

- The scope and purpose of the policy
- The relationship of the security objectives to the organization's legal and regulatory obligations, and its business objectives
- IT security requirements in terms of confidentiality, integrity, availability, accountability, authenticity, and reliability, particularly with regard to the views of the asset owners
- The assignment of responsibilities relating to the management of IT security and the organizational infrastructure
- The risk management approach adopted by the organization

14.7 The four approaches to identifying and mitigating IT risks are the:

- **baseline** approach, which implements a basic general level of security controls on systems using baseline documents, codes of practice, and "industry best practice".
- **informal** approach, which involves conducting some form of informal, pragmatic risk analysis for the organization's IT systems.
- **detailed risk analysis** process, which involves a detailed risk assessment of the organization's IT systems, using a formal structured process, providing the greatest degree of assurance that all significant risks are identified and their implications considered.
- **combined** approach, which combines elements of the baseline, informal, and detailed risk analysis approaches.

14.8 The advantages of this approach are that it provides the most detailed examination of the security risks of an organization's IT system, and produces strong justification for expenditure on the controls proposed.

The major disadvantage is the significant cost in time, resources, and expertise needed to perform such an analysis.

14.9 Risk appetite can be defined as the level of risk that an organization considers as acceptable. This depends a lot on the type of organization and its management's requirements and varies from one organization to another.

14.10 Few sources of human-made threats are:

- an insider retrieving and selling information for personal gain (deliberate)
- a hacker targeting the organization's server over the Internet (deliberate)
- an employee incorrectly entering information on a system, which results in the system malfunctioning (accidental)

14.11 Key information on determining what are key assets requires the expertise of people in the relevant areas of the organization. In contrast, identifying possible threats and threat sources requires the use of a variety of sources, along with the experience of the risk analyst. The risk analyst takes the descriptive asset and threat/vulnerability details, and in the light of the organizations overall risk environment and existing controls, decides the appropriate likelihood rating. The determination of the consequence, should any asset be compromised, relies upon the judgment of the asset's owners, and the organization's management, rather than the opinion of the risk analyst.

14.12 The following factors should be considered during threat identification:

- Motivation: Why would they target this organization; how motivated are they?
- Capability: What is their level of skill in exploiting the threat?
- Resources: How much time, money, and other resources could they deploy?
- Probability of attack: How likely and how often would your assets be targeted?
- Deterrence: What are the consequences to the attacker of being identified?

14.13 **consequence**: indicates the impact on the organization should some particular threat actually eventuate.
likelihood: the probability that an identified threat could occur and cause harm to some asset.

14.14 The simple equation for determining risk is:

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Risk = Probability that threat occurs × Cost to organization
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It is not commonly used in practice because it is often extremely hard to determine accurate probabilities, realistic cost consequences, or both. Hence most risk analyses use qualitative, rather than quantitative, ratings for both these items.

14.15 The items typically specified in the risk register for each asset/threat identified are: Asset, Threat/Vulnerability, Existing Controls, Likelihood, Consequence, Level of Risk, and Risk Priority

14.16 Five alternatives for managing identified risks are:

- **risk acceptance**: choosing to accept a risk level greater than normal for business reasons, typically due to excessive cost or time needed to treat the risk. Management must then accept responsibility for the consequences to the organization should the risk eventuate.
- **risk avoidance**: not proceeding with the activity or system that creates this risk. This usually results in loss of convenience or ability to perform some function that is useful to the organization. The loss of this capability is traded off against the reduced risk profile.
- **risk transferal**: sharing responsibility for the risk with a third-party. This is typically achieved by taking out insurance against the risk occurring, by entering into a contract with another organization, or by using partnership or joint venture structures to share the risks and costs should it eventuate.
- **reduce consequence**: by modifying the structure or use of the assets at risk to reduce the impact on the organization should the risk occur. This could be achieved by implementing controls to enable the organization to quickly recover should the risk occur.
- **reduce likelihood**: by implementing suitable controls to lower the chance of the vulnerability being exploited. These could include technical or administrative controls that aim to improve the security of the asset, making it harder for an attack to succeed by reducing the vulnerability of the asset.

ANSWERS TO PROBLEMS

14.1 Existing controls:Firewall, well defined security policies, proper access control mechanisms
Likelihood: Possible
Consequences: Major
Level of risk: Extreme

The asset concern the integrity of stored information and these could be compromised by both internal and external sources. These can be either the result of intentional malicious or fraudulent acts, or the

unintentional deletion, modification, or disclosure of information by intruders. To prevent intruders, these systems are protected by the company's outer firewall from much external access. Other than this, each organization has its own security policies and well defined access control mechanisms so that unauthorized access could be prevented. However, a likelihood rating of Possible is given as large number of systems store large amount of data on which privacy or security breach of any of the security policy is possible. There is also the possibility of serious legal consequences if personal information was disclosed or if students or faculty information is modified. Hence a consequence rating of Major was selected. This results in a risk level of Extreme.

14.2 Possible values for the risk register for this asset and threat are:

Asset	Threat/ Vulnerability	Existing Controls	Likelihood	Consequence	Level of Risk
integrity of /customer and financial data files on desktop systems	corruption of these files due to import of a worm/virus onto system	anti-virus program	Almost Certain	Major	Extreme

Given limited IT support, it is likely that the systems and A/V programs are not current, hence given the high rate of worm/virus incidents, infection is almost certain. Similarly, it is likely that such an organization does not regularly backup their data, hence such an infection could cause loss of critical customer/financial data, with serious impact on the organizations functions. Clearly changing these assumptions will change the ratings.

14.3 Existing controls: Risk assessment, hardened O/S, automated patching, intrusion detection
Likelihood: Unlikely
Consequences: Catastrophic
Level of risk: Extreme

Given that the main file server belongs to a hospital, and important information of patients is stored on server, it is reasonable to assume that it is managed according to current best practice, having undergone a risk assessment, and using a hardened O/S with automated patching and an IDS. So it is unlikely that this confidentiality attack will happen. But if it occur, it will results in a serious/ extreme damage to the hospital management as patients details loss can result in wrong treatments in future due to no history.

Hence assume a catastrophic consequence. Changing these assumptions will change the ratings.

14.4 Possible values for the risk register for this asset and threat are:

Asset	Threat/ Vulnerability	Existing Controls	Likelihood	Consequence	Level of Risk
integrity of the organizatio n's web server	hacking and defacement of the web server	-	Possible	Minor	Medium

Assuming that their website uses common CGI programs such as guestbook or blog software, then given the rate of remotely exploitable bugs found in such program, exploit is possible (and is very dependent on both how carefully their IT support tracks reports of such bugs and patches when found, and bad luck in being identified and targeted by an attacker). However whilst defacement of their site may well cause embarrassment and adverse publicity, it ought not affect the actual production work. It is also fairly easy to correct. Hence assume a minor consequence. Changing these assumptions will change the ratings.

14.5 Possible values for the risk register for this asset and threat are:

Asset	Threat/ Vulnerability	Existing Controls	Likelihood	Consequence	Level of Risk
confidentiality of techniques used to conduct penetration tests on customers, and the results of conducting such tests for clients, which are stored on the server	theft/breach of this confidential and sensitive information by either an external or internal source	risk assessed, hardened O/S, automated patching, IDS	Unlikely	Catastrophic	Extreme

Given that the main file server belongs to an IT security consultancy firm it is reasonable to assume that it is managed according to current best practice, having undergone a risk assessment, and using a hardened O/S with automated patching and an IDS. Nonetheless, given that zero-day exploits continue to be found, successful external exploit is conceivable, if unlikely. As noted in the answer to problem 14.3, insider attack is also conceivable, if very hard to predict. Should this attack occur, the damage to the firm is likely to be serious, as it attacks the core of their reputation and intellectual property. Hence assume a

catastrophic consequence. Changing these assumptions will change the ratings.

14.6 Possible values for the risk register for this asset and threat are:

Asset	Threat/ Vulnerability	Existing Controls	Likelihood	Consequence	Level of Risk
confidentiality of personnel information in a copy of a database stored unencrypted on the laptop	theft of personal information, and its subsequent use in identity theft caused by the theft of the laptop	insurance	Possible	Major	Extreme

Given the very high report rate of laptop theft (e.g. the 2006 CSI/FBI survey shows 47% of respondents suffered from this), if the data stored on the laptop is not encrypted (as is still common), then the chances of it being accessed and used in identity theft is possible – depending on the motivations and skills of the thief. Hence assume a rating of possible for this specific threat. A number of large government departments and agencies have been embarrassed, and suffered significant financial penalties, as a result of such a theft in recent years. Hence assume a consequence of major. Changing these assumptions will change the ratings.

14.7 Adversarial (Individual, Group, Organization, Nation-State), Accidental, Structural (IT Equipment, Controls, Software), and Environmental (Natural Or Man-Made Disaster, Unusual Natural Event, Infrastructure Failure/Outage).
Other threats include- price manipulation, spamming, Malicious code threats- typically involve viruses, worms, Trojan horses.

14.8 NIST SP 800-30 (2002) Tables 3-4 to 3-7 use a 3 level scale of high/medium/low for each of likelihood, consequence and risk, while our Tables 14.2 to 14.4 use 5, 6, and 4 levels respectively. This means that assessments using our ratings can use a finer level of granularity, and potentially better separate different asset/threat items, than assessments done using the NIST tables. However having a greater number of levels means that it can be harder to determine the most appropriate rating (although some small changes do not alter the final resultant risk level).

CHAPTER 15 IT SECURITY CONTROLS, PLANS, AND PROCEDURES

ANSWERS TO QUESTIONS

15.1 **Security controls** or **safeguards** are practices, procedures or mechanisms that may protect against a threat, reduce a vulnerability, limit the impact of an unwanted incident, or detect unwanted incidents and facilitate recovery.

15.2 The three broad classes of controls are:

- **management control:** focus on security policies, planning, guidelines and standards which then influence the selection of operational and technical controls to reduce the risk of loss and to protect the organization's mission.
- **operational control:** address the correct implementation and use of security policies and standards, ensuring consistency in security operations, and correcting identified operational deficiencies.
- **technical controls:** involve the correct use of hardware and software security capabilities in systems.

In turn, each of these control classes may include:

- **supportive controls:** pervasive, generic, underlying technical IT security capabilities that are interrelated with, and used by many other controls.
- **preventative controls:** focus on preventing security breaches from occurring, by inhibiting attempts to violate security policies or exploit a vulnerability.
- **detection and recovery controls:** focus on the response to a security breach, by warning of violations or attempted violations of security policies or the identified exploit of a vulnerability, and by providing means to restore the resulting lost computing resources.

15.3 To list a specific example of each of three broad classes of controls from those given in Table 15.3, first use Table 15.1 which classifies the control families into the relevant class, then select any suitable entry from a suitable control family in Table 15.3 for each. If further details are wanted, consult [NIST09] for detailed information on each item.

15.4 To attain an acceptance level of security, as suggested by NIST, the following adjustments may be required which should be addressed.

- **Technology:** Some controls are only applicable to specific technologies, and hence these controls are only needed if the system includes those technologies. Examples of these include wireless networks and the use of cryptography. Some may only be appropriate if the system supports the technology they require -- for example, readers for access tokens. If these technologies are not supported on a system, then alternate controls, including administrative procedures or physical access controls, may be used instead.
- **Common Controls:** The entire organization may be managed centrally and may not be the responsibility of the managers of a specific system. Control changes would need to be agreed to and managed centrally.
- **Public Access Systems:** Some systems, such as the organization's public Web server, are designed for access by the general public. Some controls, such as those relating to personnel security, identification, and authentication, would not apply to access via the public interface. They would apply to administrative control of such systems. The scope of application of such controls must be specified carefully.
- **Infrastructure Controls:** Physical access or environmental controls are only relevant to areas housing the relevant equipment.
- **Scalability Issues:** Controls may vary in size and complexity in relation to the organization employing them. For example, a contingency plan for systems critical to a large organization would be much larger and more detailed than that for a small business.
- **Risk Assessment:** Controls may be adjusted according to the results of specific risk assessment of systems in the organization, as we now consider.

15.5 Implementing a new or enhanced control can reduce the residual level of risk as a result of the reduction in threat likelihood from either reducing vulnerabilities/flaws/weaknesses in the system, or by reducing the capability and motivation of the threat source; or from a reduction in consequence by reducing the magnitude of the adverse impact of the threat occurring on the organization.

15.6 Following are the factors that are considered while selecting controls for cost-benefit analysis:

- If the control would reduce risk more than needed, then a less expensive alternative could be used.
- If the control would cost more than the risk reduction provided, then an alternative should be used.
- If a control does not reduce the risk sufficiently, then either more or different controls should be used.

- If the control provides sufficient risk reduction and is the most cost effective, then use it.

15.7 The elements that form the "Implementation of Controls" phase of IT security management include:
- implementation of the security plan (where the identified personnel undertake the tasks needed to implement the new or enhanced controls).
- security training (of the personnel responsible for the development, operation and administration of the system being installed or enhanced)
- security awareness (training for all personnel in an organization to assist it in meeting the security objectives).

15.8 Security compliance checking is an audit process to review the organization's security processes and hence, the main goal of this process is to verify compliance with the security plan.

This process is usually conducted on new IT systems and services once they are implemented; and on existing systems periodically, often as part of a wider, general audit of the organization or whenever changes are made to the organization's security policy.

15.9 Change management is an important component of systems administration process because it evaluates the implications of the proposed change on the organization's system. This includes not only security-related aspects, but wider operational issues as well.

Change management may be an informal or a formal process, depending on the size of the organization and its overall IT management processes.

15.10 Because changes can affect security, the general process of change and configuration management overlaps IT security management and must interact with it.

ANSWERS TO PROBLEMS

15.1 To manage the risk to "integrity of customer and financial data files on system" from "corruption of these files due to import of a worm/virus onto system (exercise 14.2), some suitable specific controls from Table 15.3 could include: Security Awareness training, Access Restrictions for Change, Periodic and Timely Systems Maintenance, Malicious Code Protection, Intrusion Detection Tools and Techniques, Spam and Spyware Protection. The most cost-effective controls are likely to include Malicious Code Protection and Spam and Spyware Protection to

identify and block infections, along with Periodic and Timely Systems Maintenance to keep the system patched.

15.2 To manage the risks to ``confidentiality of personal medical records stored on a hospital server from the theft of confidential and sensitive information, and its subsequent use in identity theft caused by the breach of server database, (exercise 14.3), some suitable specific controls from Table 15.3 could include: Access control for portable and mobile systems, Security awareness training, Physical access control, personal sanctions, Use of validated cryptography. The most cost effective controls are likely to include the use of validated cryptography and access control for portable devices and server database to ensure any sensitive information is encrypted and hence cannot be accessed as a result of theft, along with security awareness training and personal sanctions to help limit the transfer of sensitive information to such devices. Moreover, the use of modern cryptosystems such as homomorphic encryption with restricted access control to the encrypted data must be guaranteed to provide the solution for the theft/breach of confidential and sensitive information from hospital sever database.

15.3 To manage the risk to "integrity of the organization's web server" from "hacking and defacement of the web server" (exercise 14.4), some suitable specific controls from Table 15.3 could include: Access Restrictions for Change, Periodic and Timely Systems Maintenance, Flaw Remediation, Incident Handling, Vulnerability Scanning, Intrusion Detection Tools and Techniques, Security Alerts and Advisories. The most cost-effective controls are likely to include Periodic and Timely Systems Maintenance and Flaw Remediation to try and reduce the likelihood of the web server running buggy software, along with good Incident Handling processes to react and correct the system should the threat occur.

15.4 To manage the risk to "confidentiality of techniques for conducting penetration tests on customers, and the results of these tests, which are stored on the server" from "theft/breach of this confidential and sensitive information" (exercise 14.5), some suitable specific controls from Table 15.3 could include: Account Management, Access Enforcement, Separation of Duties, Least Privilege, Audit Monitoring, Analysis, and Reporting, Audit Reduction and Report Generation, User Identification and Authentication, Periodic and Timely Systems Maintenance, Flaw Remediation, Personnel Screening, Personnel Sanctions, Intrusion Detection Tools and Techniques. Given the seriousness of the consequences, controls should focus on reducing the likelihood of this threat occurring, hence the most cost-effective controls are likely to include Personnel Screening, Personnel Sanctions, User Identification and Authentication, Access Enforcement, and

Separation of Duties to help manage insider threats; and Periodic and Timely Systems Maintenance, Flaw Remediation, and Intrusion Detection Tools and Techniques to help manage external threats.

15.5 To manage the risk to "confidentiality of personnel information in a copy of a database stored unencrypted on the laptop" from "theft of personal information, and its subsequent use in identity theft caused by the theft of the laptop" (exercise 14.6), some suitable specific controls from Table 15.3 could include: Access Control for Portable and Mobile Systems, Security Awareness Training, Physical Access Control, Personnel Sanctions, Use of Validated Cryptography. The most cost-effective controls are likely to include the Use of Validated Cryptography and Access Control for Portable and Mobile Systems to ensure any sensitive information is encrypted and hence cannot be accessed as a result of the theft, along with Security Awareness Training and Personnel Sanctions to help limit the transfer of sensitive information to such devices, and to adjust behavior to reduce the chance of such thefts occurring.

15.6 In managing the risks identified in the assessment of a small e-commerce firm (exercise 14.7), clearly a very wide range of controls are applicable. Depending on the assumptions made and the current environment, what are considered the most critical risks can vary considerably. However these would likely include the common natural environment threats (fire, flood, failure of power/water/air conditioning). Against these, suitable contingency planning and physical, and environmental protection control should be chosen. Critical risks would also include those due to accidental insider actions such as operational errors, and the input of valid information. Against these controls from the awareness and training and audit and accountability sections should be chosen. In the case of deliberate insider threats (fraud, same information etc.), audit and accountability and personal controls could be used. Lastly for external attacks, controls relating to access controls, configuration management, contingency planning and incident response can be used.

CHAPTER 16 PHYSICAL AND INFRASTRUCTURE SECURITY

ANSWERS TO QUESTIONS

16.1 Infrastructure security protects the information systems that contain data and the people who use, operate, and maintain the systems. It also prevents any type of physical access or intrusion that can compromise logical security.

Premises security, on the other hand, protects the people and property within an entire area, facility, or building(s), and is usually required by laws, regulations, and fiduciary obligations. It also provides environmental protection, smoke and fire detection, etc.

16.2 Three different categories of human-caused physical threats are:

1. **Unauthorised Physical Access:** Any unauthorized person should not be allowed to access any resources. It may cause physical damages as well as other type of threats, such as theft or misuse.
2. **Theft:** An unauthorized access may lead to copying of sensitive data, eavesdropping as well as wiretapping.
3. **Vandalism:** This type of physical threats includes destruction of resources as well as data.

16.3 The following are the threats posed by water:

- an electrical short can happen if water bridges between a circuit board trace carrying voltage and a trace carrying ground.
- a pipe may burst from a fault in the line or from freezing.
- a burst pipe or a faulty sprinkler system may cause water to enter the computer rooms.
- floodwater can lead to catastrophic situation because it has a muddy residue which can damage crucial components of a computer.

16.4 Dealing with this problem is primarily a matter of having environmental-control equipment of appropriate capacity and appropriate sensors to warn of thresholds being exceeded. Beyond that, the principal requirement is the maintenance of a power supply.

16.5
1. Choice of site to minimize likelihood of disaster. Few disastrous fires originate in a well-protected computer room or IS facility. The IS area should be chosen to minimize fire, water, and smoke hazards from adjoining areas. Common walls with other activities should have at least a one-hour fire-protection rating.
2. Air conditioning and other ducts designed so as not to spread fire. There are standard guidelines and specifications for such designs.
3. Positioning of equipment to minimize damage.
4. Good housekeeping. Records and flammables must not be stored in the IS area. Tidy installation if IS equipment is crucial.
5. Hand-operated fire extinguishers readily available, clearly marked, and regularly tested.
6. Automatic fire extinguishers installed. Installation should be such that the extinguishers are unlikely to cause damage to equipment or danger to personnel.
7. Fire detectors. The detectors sound alarms inside the IS room and with external authorities, and start automatic fire extinguishers after a delay to permit human intervention.
8. Equipment power-off switch. This switch must be clearly marked and unobstructed. All personnel must be familiar with power-off procedures.
9. Emergency procedures posted.
10. Personnel safety. Safety must be considered in designing the building layout and emergency procedures.
11. Important records stored in fireproof cabinets or vaults.
12. Records needed for file reconstruction stored off the premises.
13. Up-to-date duplicate of all programs stored off the premises.
14. Contingency plan for use of equipment elsewhere should the computers be destroyed.
15. Insurance company and local fire department should inspect the facility.

16.6 Prevention and mitigation measures for water threats must encompass the range of such threats. For plumbing leaks, the cost of relocating threatening lines is generally difficult to justify. With knowledge of the exact layout of water supply lines, measures can be taken to locate equipment sensibly. The location of all shutoff valves should be clearly visible or at least clearly documented, and responsible personnel should know the procedures to follow in case of emergency. To deal with both plumbing leaks and other sources of water, sensors are vital. Water sensors should be located on the floor of computer rooms, as well as under raised floors, and should cut off power automatically in the event of a flood.

16.7 To deal with brief power interruptions, an uninterruptible power supply (UPS) should be employed for each piece of critical equipment. The UPS is a battery backup unit that can maintain power to processors,

monitors, and other equipment for a period of minutes. UPS units can also function as surge protectors, power noise filters, and automatic shutdown devices when the battery runs low. For longer blackouts or brownouts, critical equipment should be connected to an emergency power source, such as a generator. For reliable service, a range of issues need to be addressed by management, including product selection, generator placement, personnel training, testing and maintenance schedules, and so forth.

ANSWERS TO PROBLEMS

16.1 The World Bank checklist specifically mentions the following items not covered by the Security Policy: biometric and smart card access control techniques; checking audit trails; storage of backup data securely; unused ports turned off; use of surveillance cameras; fire suppression equipment; humidity controls; ceiling reinforcement. The Security Policy is general but goes into more detail than the checklist on procedures and general areas of concern. It is interesting to note that in fact there are quite a few areas covered in each document that are not covered in the other. Both are meant as guidelines but clearly neither is exhaustive.

16.2 The chapter generally covers all of the areas mentioned in the two documents.

16.3 The Security Policy covers in general terms the areas that are covered in more detail in Sections 16.1 through 16.3 of this chapter. It does not cover the material in Sections 16.4, 16.5, and 16.7. The scope of this chapter is broader.

16.4 There is no unique set of answers to this question. The following is one set.

	IT Security	Physical Security
Boundary type (what constitutes the perimeter)	Complex boundaries that combine hardware, software and networks (VPN, Web browsing, database, wireless)	Discrete, well-defined boundaries (vaults, building walls, containers)
Standards	Customers demand interoperability; equal mix of standards-based and proprietary systems	Some infrastructure uses commodity parts, but systems are generally proprietary and not interoperable
Maturity	Rapid evolution of products	Industry has 100-plus years of processes and response system; longer product cycles
Frequency of attacks	High: attacks often scale quickly, with active communities discussing well-known attacks	Low: attacks tend to be localized and repeated less often
Attack responses (types of responses)	Effective patch management and update mechanisms	Security fixes and firmware updates applied in nonuniform fashion
Risk to attackers	Few: hard to trace sophisticated attacks	High: adversary risks physical arrest/capture
Evidence of compromise	Varies, hard to tell if data were copied	Stolen items are noticed missing.

CHAPTER 17 HUMAN RESOURCES SECURITY

ANSWERS TO QUESTIONS

17.1
- Improving employee behavior
- Increasing the ability to hold employees accountable for their actions
- Mitigating liability of the organization for an employee's behavior
- Complying with regulations and contractual obligations

17.2 Some of the goals of a security awareness program are:

1. Awareness among staff about IT related security issues.
2. To ensure that staff is aware of different set of laws.
3. Train staff to meet the specific security responsibilities of their positions.
4. To explain organizational security policies.
5. Remind staff that breaches in security carry consequences.

17.3 The main difference between security training and security education is that security training is designed to teach staffs the skills required to handle their tasks more securely, however, the security education is more specialized and in-depth program of an employee career development.

17.4 **Hiring**: to ensure that employees, contractors, and third-party users understand their responsibilities and are suitable for the roles they are considered for, and to reduce the risk of theft, fraud, or misuse of facilities.

During employment: to ensure that employees, contractors, and third-party users are aware of information security threats and concerns and their responsibilities and liabilities with regard to information security and are equipped to support organizational security policy in the course of their normal work and to reduce the risk of human error.

Terminating employment: to ensure that employees, contractors, and third-party users exit an organization or change employment in an orderly manner, and that the return of all equipment and the removal of all access rights are completed.

17.5 ISO 27002 is a comprehensive set of controls comprising best practices in information security. It is essentially an internationally recognized generic information security standard.

17.6

1. **Background Checks and Screening:** The background check is very important and crucial process during hiring process. The large number of resumes and considering the fact that people may inflate their resume makes this process challenging.
2. **Employment Agreements:** The staff should read, understand and sign the employment agreement. The employment agreement includes responsibilities of organisation as well as employee for information security. This agreement should include confidently and nondisclosure agreement of organisation's information assets.

17.7

1. Significant employee work time may be consumed in non-work-related activities, such as surfing the Web, playing games on the Web, shopping on the Web, chatting on the Web, and sending and reading personal e-mail.
2. Significant computer and communications resources may be consumed by such non-work-related activity, compromising the mission that the IS resources are designed to support.
3. Excessive and casual use of the Internet and e-mail unnecessarily increases the risk of introduction of malicious software into the organization's IS environment.
4. The non-work-related employee activity could result in harm to other organizations or individuals outside the organization, thus creating a liability for the organization.
5. E-mail and the Internet may be used as tools of harassment by one employee against another.
6. Inappropriate online conduct by an employee may damage the reputation of the organization.

17.8 The benefits of developing an incident response capability include: responding to incidents systematically so that the appropriate steps are taken; helping personnel to recover quickly and efficiently from security incidents, minimizing loss or theft of information, and disruption of services; using information gained during incident handling to better prepare for handling future incidents and to provide stronger protection for systems and data; and dealing properly with legal issues that may arise during incidents.

17.9 The broad categories of security incidents include various forms of unauthorized access to a system, and various forms of unauthorized modification of information on the system.

17.10 Some types of tools used to detect and respond to incidents are: system integrity verification tools, log analysis tools, network and host intrusion detection systems, and intrusion prevention systems.

17.11 Following the immediate response to an incident, there is a need to identify what vulnerability led to its occurrence, and how this might be addressed to prevent it occurring in future. Details of the incident, and the response taken are recorded for future reference. The impact on the organization's systems, and their risk profile must also be reconsidered as a result of the incident.

ANSWERS TO PROBLEMS

17.1 Mainly there are two ways in which an employee may violate the security: unwillingly and willingly. Example of the former case includes leaving their computers unattended and that of the latter includes copying files from the organization's computer to his/her pendrive to steal the data.

17.2 **a.** Taking photo copies of the organization's legal documents without prior permission should be forbidden in the policy. The janitor should be fired. If the policy did not include this, fire the janitor for goofing off.

b. Rewrite the policy to state that taking photo copies of organization's legal documents without permission is forbidden at the worksite.

17.3 Leaving the computer unattended for a long period of time is unsafe since there are chances of sensitive data getting leaked, without David having any idea about it. Forbid leaving the computer unattended for that reason.

17.4 Data cables should be addressed in the policy and forbidden on work grounds because people can use them to connect to the organization's computer and steal the sensitive data. Additionally, security personnel should look into USB blocking. Data cables should be left with security until Alice goes home that day with clear instructions NOT to bring one to work.

17.5 Key loggers can be very risky for the organization's data. Dump the software. Inform Ema that this is a serious violation of security. Write her up or fire her if the policy says. If not, add it to the policy and warn her.

17.6 All employees should sign agreement to notify company of any published articles or upcoming articles and must agree not to discuss company stuff in a general or specific way in the article. Security

personnel should be reading the articles of every employee who has one to ensure that the content of the article is in line with confidentiality and security procedures. If the company has company magazine, only specific employees would be allowed to write articles in it and those articles must be preapproved. George must agree to avoid pointing to that link in future articles and is not entitled to write articles during work time (even if it is during his breaks).

17.7 In the incident response policy for the small accounting firm (exercises 14.2 and 15.1), in response to the detection of an email worm infecting some of the company systems and producing large volumes of email spreading the propagation, if the indications are that the infection is seriously compromising the external network connections, and the risk of further infection is high, then disconnecting the firm's systems from the Internet to limit further spread is a reasonable policy. Whilst recognizing this will impact email/web communications and hence the firm's operations, it is still likely the better option than contributing to the further spread of the infection. The policy would most likely also recommend reporting the incident to the appropriate Computer Emergency Response Team (CERT), but not as a matter of urgency (if it is large enough, they will know about it). It would not recommend reporting it to law enforcement authorities, since its unlikely that legal action in response is possible.

17.8 In the incident response policy for the small legal firm (exercises 14.3 and 15.2), in response to the detection of significant financial fraud by an employee, initial actions should include isolating the suspected staff member from any access to the firm's systems, and arranging for a forensic copy to be made of all relevant data, especially audit records of actions taken on the system, in the event of future legal action. This incident should be reported to the relevant law enforcement authorities to allow them to respond and collect evidence needed. Ideally it should also be reported in general terms to the relevant Computer Emergency Response Team (CERT) to allow them to compile accurate statistics of computer crime incidents.

17.9 In the incident response policy for the web design company (exercises 14.4 and 15.3), in response to the detection of hacking and defacement of their web server, it would most likely NOT recommend disconnecting the system from the Internet to limit damaging publicity, but rather immediately restoring the defaced pages from backups, and initiating action to identify the vulnerability exploited to allow the attack, and taking immediate steps to block access to it (which may involve removing some functionality from the system pending further analysis and corrective action). This is more likely an appropriate response than complete disconnection, as the web site is needed to promote the company's operations. The policy would most likely also

recommend immediately reporting the incident to the appropriate Computer Emergency Response Team (CERT), as they may be able to advise whether it is part of a larger coordinated attack, and perhaps supply additional information on countering it. It would not recommend reporting it to law enforcement authorities unless there is evidence identifying the attacker, since otherwise it is unlikely that legal action in response is possible.

17.10 In the incident response policy for the large government department (exercises 14.6 and 15.5), in response to the report of theft of a laptop containing a large number of sensitive personnel records, the policy will likely be bound by legal requirements which increasingly mandate contacting the personnel whose records have been stolen, and most likely requiring the government to provide monitoring of their credit records for some period. Assuming the department has policies concerning the circumstances under which sensitive information can be transferred to laptops, if these were not followed then the relevant sanctions should be imposed against the employee whose laptop was stolen. If the department does not have such policies, this lack should be highlighted as a consequence of the development of this policy, and management warned that serious adverse publicity and financial costs are possible should this risk occur. Legal requirements increasingly mandate that the incident should be reported to the relevant law enforcement authorities, and/or government security agency, to allow them to respond appropriately. Ideally it should also be reported in general terms to the relevant Computer Emergency Response Team (CERT) to allow them to compile accurate statistics of computer crime incidents.

CHAPTER 18 SECURITY AUDITING

ANSWERS TO QUESTIONS

18.1 An event discriminator is a logical module that detects security-relate event. Each such event triggers a **security audit message** to an audit recorder. Thus the message simply causes the detected event to be recorded. If the event requires some defensive action, the event discriminator sends a **security alarm** on this even to an alarm processor to trigger the action. Thus a security alarm results in an action.

18.2 • Event discriminator: The is logic embedded into the software of the system that monitors system activity and detects security-related events that it has been configured to detect.
• Audit recorder: For each detected event, the event discriminator transmits the information to an audit recorder. The model depicts this transmission as being in the form of a message. The audit could also be done by recording the event in a shared memory area.
• Alarm processor: Some of the events detected by the event discriminator are defined to be alarm events. For such events an alarm is issued to an alarm processor. The alarm processor takes some action based on the alarm. This action is itself an auditable event and so is transmitted to the audit recorder.
• Security audit trail: The audit recorder creates a formatted record of each event and stores it in the security audit trail.
• Audit analyzer: The security audit trail is available to the audit analyzer, which, based on a pattern of activity, may define a new auditable event that is sent to the audit recorder and may generate an alarm.
• Audit archiver: This is a software module that periodically extracts records from the audit trail to create a permanent archive of auditable events.
• Archives: The audit archives are a permanent store of security-related events on this system.
• Audit provider: The audit provider is an application and/or user interface to the audit trail.
• Audit trail examiner: The audit trail examiner is an application or user who examines the audit trail and the audit archives for historical trends, for computer forensic purposes, and for other analysis.

• Security reports: The audit trail examiner prepares human-readable security reports.

18.3 • Data generation: Identifies the level of auditing, enumerates the types of auditable events, and identifies the minimum set of audit-related information provided. This function must also deal with the conflict between security and privacy and specify for which events the identity of the user associated with an action is included in the data generated for an event.
• Event selection: Inclusion or exclusion of events from the auditable set. This allows the system to be configured at different levels of granularity to avoid the creation of an unwieldy audit trail.
• Event storage: Creation and maintenance of the secure audit trail. The storage function includes measures to provide availability and to prevent loss of data from the audit trail.
• Automatic response: Defines reactions taken following detection of events that are indicative of a potential security violation.
• Audit analysis: Provided via automated mechanisms to analyze system activity and audit data in search of security violations. This component identifies the set of auditable events whose occurrence or accumulated occurrence indicates a potential security violation. For such events, an analysis is done to determine if a security violation has occurred; this analysis uses anomaly detection and attack heuristics.
• Audit review: As available to authorized users to assist in audit data review. The audit review component may include a selectable review function that provides the ability to perform searches based on a single criterion or multiple criteria with logical (i.e. and/or) relations, sort audit data, and filter audit data before audit data are reviewed. Audit review may be restricted to authorized users.

18.4 • Introduction of objects within the security-related portion of the software into a subject's address space
• Deletion of objects
• Distribution or revocation of access rights or capabilities
• Changes to subject or object security attributes
• Policy checks performed by the security software as a result of a request by a subject
• The use of access rights to bypass a policy check
• Use of identification and authentication functions
• Security-related actions taken by an operator and/or authorized user (e.g., suppression of a protection mechanism)
• Import/export of data from/to removable media (e.g., printed output, tapes, disks)

18.5 **System-level audit trails:** captures data such as login attempts, both successful and unsuccessful, devices used, and OS functions performed

Application-level audit trails: may be used to detect security violations within an application or to detect flaws in the application's interaction with the system.
User-level audit trails: traces the activity of individual users over time.
Physical access audit trails: generated by equipment that controls physical access and then transmitted to a central host for subsequent storage and analysis.

18.6 Protection of the audit trail involves both integrity and confidentiality. Integrity is important because an intruder may attempt to remove evidence of the intrusion by altering the audit trail. For file system logging, perhaps the best way to ensure integrity is the digital signature. Write-once devices, such as CD-ROM or paper, automatically provide integrity. Strong access control is another measure to provide integrity. Confidentiality is important if the audit trail contains user information that is sensitive and should not be disclosed to all users, such as information about changes in a salary or pay grade status. An effective measure is symmetric encryption (e.g., using AES [Advanced Encryption Standard] or triple DES [Data Encryption Standard]). The secret key must be protected and only available to the audit trail software and subsequent audit analysis software.

18.7 This technique described provides for application-level auditing by creating new procedures that intercept calls to shared library functions in order to instrument the activity.

18.8 • Audit analysis: Provided via automated mechanisms to analyze system activity and audit data in search of security violations. This component identifies the set of auditable events whose occurrence or accumulated occurrence indicates a potential security violation. For such events, an analysis is done to determine if a security violation has occurred; this analysis uses anomaly detection and attack heuristics.
• Audit review: As available to authorized users to assist in audit data review. The audit review component may include a selectable review function that provides the ability to perform searches based on a single criterion or multiple criteria with logical (i.e. and/or) relations, sort audit data, and filter audit data before audit data are reviewed. Audit review may be restricted to authorized users.

18.9 **Baselining** is the process of defining normal versus unusual events and patterns. The baseline values are computed and then compared to new data to detect unusual shifts. **Thresholding** is the identification of data that exceed a particular baseline value. **Windowing** is detection of events within a given set of parameters, such as within a given time period or outside a given time period.

ANSWERS TO PROBLEMS

18.1 **a.** The X.800 series is specifically concerned with networking and telecommunications, so you would expect a more network-based orientation than ISO 27002, which is focused on information and computer security. This is reflected in Tables 18.2 and 18.3. For example, X.816 refers to connection-related security events, and ISO 27002 does not.

b. An example of the ISO 27002 focus on computer security is the set of events related to privileged operations. X.816 has not comparable events.

18.2 **a.** X.816, with its orientation to the OSI model, refers to events related to the layers of that model in a way that Table 18.6 does not. The items in ISO 27002 are fairly well covered in Table 18.6.

b. Table 18.6 is a lengthier and more detailed list. As such, it provides perhaps more useful guidance in developing a specific list of events.

18.3 MARS works with agentless configuration. NetFlow is an open but proprietary network protocol developed by Cisco Systems to run on network equipment, such as routers and LAN switches, for collecting IP traffic information. Yes, it is compatible with MARS.

CHAPTER 19 LEGAL AND ETHICAL ASPECTS

ANSWERS TO QUESTIONS

19.1 Table 19.1.

19.2 The IP for which legal protection are available are: Copyrights, trademarks, and patents. The legal protection is against infringement of these. Depending upon the type of IP, infringements may vary.

19.3 • Copyrights: Copyright law protects the tangible or fixed expression of an idea, not the idea itself.
• Trademarks: A trademark is a word, name, symbol, or device that is used in trade with goods to indicate the source of the goods and to distinguish them from the goods of others.
• Patents: A patent for an invention is the grant of a property right to the inventor.

19.4 (1) The proposed work is original. (2) The creator has put this original idea into a concrete form, such as hard copy (paper), software, or multimedia form.

19.5 The following are three types of patents:

- **Utility patents:** are granted to the one who invents or discovers any new and useful process, machine, article of manufacture, or composition of matter, or any new and useful improvement thereof.
- **Design patents:** granted to the one who invents a new, original, and ornamental design for an article of manufacture.
- **Plant patents:** granted to the one who invents or discovers and asexually reproduces any distinct and new variety of plant.

19.6 The following actions are exempted from the DMCA and other copyright laws: Fair use, Reverse engineering, Encryption research, Security testing, and Personal privacy.

19.7 Anonymity ensures that a user may use a resource or service without disclosing the user's identity and the system will not solicit the real name of a user. With pseudonymity, the user is accountable for using

a resource or service although its identity is disclosed i.e., the system can determine the user's identity.

19.8 • Content provider: Holds the digital rights of the content and wants to protect these rights. Examples are a music record label and a movie studio.
• Distributor: Provides distribution channels, such as an online shop or a Web retailer. For example, an online distributor receives the digital content from the content provider and creates a Web catalog presenting the content and rights metadata for the content promotion.
• Consumer: Uses the system to access the digital content by retrieving downloadable or streaming content through the distribution channel and then paying for the digital license. The player/viewer application used by the consumer takes charge of initiating license request to the clearinghouse and enforcing the content usage rights.
• Clearinghouse: Handles the financial transaction for issuing the digital license to the consumer and pays royalty fees to the content provider and distribution fees to the distributor accordingly. The clearinghouse is also responsible for logging license consumptions for every consumer.

19.9 Table 19.3.

19.10 The Common Criteria specification is primarily concerned with the privacy of an individual with respect to that individual's use of computer resources, rather than the privacy of personal information concerning that individual.

19.11 **Consent:** ensuring participants can make informed decisions about their participation in the research
Privacy and confidentiality: privacy is the control that individuals have over who can access their personal information. Confidentiality is the principle that only authorized persons should have access to information.
Ownership and authorship: addresses who has responsibility for the data, and at what point does an individual give up their right to control their personal data.
Data sharing – assessing the social benefits of research: that result from data matching and re-use of data from one source or research project in another
Governance and custodianship: oversight and implementation of the management, organization, access, and preservation of digital data.

19.12 **1.** A code can serve two inspirational functions: as a positive stimulus for ethical conduct on the part of the professional, and to instill confidence in the customer or user of an IS product or

service. However, a code that stops at just providing inspirational language is likely to be vague and open to an abundance of interpretations.

2. A code can be educational. It informs professionals about what should be their commitment to undertake a certain level of quality of work and their responsibility for the well being of users of their product and the public, to the extent the product may affect nonusers. The code also serves to educate managers on their responsibility to encourage and support employee ethical behavior and on their own ethical responsibilities.
3. A code provides a measure of support for a professional whose decision to act ethically in a situation may create conflict with an employer or customer.
4. A code can be a means of deterrence and discipline. A professional society can use a code as a justification for revoking membership or even a professional license. An employee can use a code as a basis for a disciplinary action.
5. A code can enhance the profession's public image, if it is seen to be widely honored.

ANSWERS TO PROBLEMS

19.1 **Article 2 Illegal access**: This is a general threat the could fall into any of the three categories, depending on what use is made of the access.
Article 3 Illegal interception: Computer as target, attack on data confidentiality.
Article 4 Data interference: Computer as target, attack on data integrity.
Article 5 System interference: Computer as target, various attack types.
Article 6 Misuse of devices: Primarily computer as communications tool.
Article 7 Computer-related forgery: Computer as target, data integrity or privacy.
Article 8 Computer-related fraud: Computer as communications tool
Article 9 Offenses related to child pornography: Computer as communications tool.
Article 10 Infringements of copyright and related rights: Computer as communications tool.
Article 11 Attempt and aiding or abetting: Computer as communications tool.

19.2 Ethics refers to a system of moral principles that relates to the benefits and harms of particular actions, and to the rightness and wrongness of

motives and ends of those actions. This basic ethical principles developed by civilizations is also applicable to computer and information system security. The WannaCry ransomware attack is a worldwide cyberattack which targeted computers running the Microsoft Windows operating system by encrypting data and demanding ransom payments in the Bitcoin cryptocurrency. It has caused economic loss about $4 billion. Therefore it was applied with wrong motive and considered as an unethical hack.

19.3 There is no simple answer to this problem, as it depends on which survey is reviewed, given that the details do change from year to year and region to region. Any answer should note significant changes in the types of crime reported, and differences between the survey results and those shown in Table 19.2.

19.4 There is no single answer to this problem. However a web search on 'DeCSS' should be done. Two key current sites are the Gallery of CSS Descramblers at CMU (http://www.cs.cmu.edu/~dst/DeCSS/Gallery/) and the Wikipedia DeCSS page which both provide many details and further links on the case. Given the very large number of items in the Gallery of CSS Descramblers (http://www.cs.cmu.edu/~dst/DeCSS/Gallery/) it is fair to conclude that the MPAA failed to suppressing details of the DeCSS descrambling algorithm.

19.5 If a person purchases a track from the iTunes store, protected by Apple's FairPlay DRM, by an EMI artist, then the DRM component roles shown in Figure 19.3 in this case are: Content Provider is EMI, Distributor and Clearinghouse are both handled by the iTunes Store, and the Consumer is the person purchasing the track.

19.6 The most common cybercrime in social media is cyberbullying. Cyberbullying is the use of information technology to repeatedly harm or harass other people in a deliberate manner. The major concern to privacy results from the rapid rise in the use of public social media sites. Current research shows that cyberbullying on social media is rapidly increasing depression in teenagers and their rate of suicides. Therefore, preserving individual privacy is of utmost importance. However, for law enforcement agencies, cybercrime presents several difficulties and challenges and hence there is a lack of proper law and corresponding justice. Only preventive measures can be useful considering current scenario. Thus preserving privacy is still the choice/responsibility of individual.

19.7 The legal protection for patented property is against infringement, which is the invasion of the rights secured by patents. The right to seek civil recourse against anyone infringing his or her property is

granted to the patent owner. The infringement includes unauthorized making, using, or selling of the patented property. If the software created by different individual is distributed as open source project after providing license fee to the patent owner, it is not a breach else it may be considered as breach of IPR. However, most of countries place some limits on the patenting of inventions involving software or completely exclude software patentability.

19.8 There is considerable overlap in spirit. The guidelines in the problem are perhaps more oriented to specific management action. They serve as a useful supplement to the standardized checklist of items in the Standard of Good Practice.

19.9 In this scenario, the administrator has very likely broken the law (though it depends on the jurisdiction applying), and breached company policy (provided they actually had one), even if for potentially altruistic reasons. The actions likely violated several of the potential ethical dilemmas listed in Table 19.3 including employee monitoring (in checking their passwords), hacking (in accessing the password files from other sections), and even internal privacy (knowing other user's passwords gives access to their data that you otherwise do not have authorization for). You might defend yourself by arguing that as a systems administrator you were authorized to access the password file. Unfortunately you are not the administrator for the section whose password file was cracked, and it will be difficult to argue that you had authority to do so. You would also have to argue that you had no intent to use that data to break any law, that your motives were not malicious and that they were in the interests of the organization and its employees. You might support these arguments by referring to item 2.5 (analysis of risks) in the ACM code, and item 7 (correct errors) in the IEEE code. The counter argument is that you failed to obey for example item 2.8 (authorized access) in the ACM code. Clearly the outcome would have been more satisfactory if the administrator had raised the issue of password security with senior management, and been granted permission to conduct the survey of current password security in a manner consistent with the law and company policy.

19.10 Assume appropriate section and subsection numbering for AITP.

	ACM	IEEE	AITP
dignity and worth of people	1.2	8, 9	—
personal integrity	Section 2	2, 3, 4	2.1, 3.6
responsibility for work	Section 2	1	1.3
confidentiality of information	1.7, 1.8	—	3.1, 4.5
public safety, health, and welfare	1.1, 1.2	1	3.3
participation in professional societies	—	—	—
knowledge about technology related to social power.	2.7	5	4.8

19.11 **a.** EC1.2, EC2.2, and EC4.1 seem designed more to protect ACM's reputation than to focus on the professionals ethical responsibility and so can reasonably be excluded. EC 2.3 and EC 3.1 are not explicit in the 1997 Code and perhaps should be. They are covered implicitly however.

b. In a number of areas, the 1997 Code is more detailed and more explicit, which provides better guidance to the professional. For example, the 1997 Code includes references to being aware of the legal responsibilities of professionals and managerial obligations.

19.12 **a.** I.3 refers to adequate compensation; this does not seem to be on target for an ethics code. II.b refers to disseminating information. Even though this is qualified with respect to legal and proprietary restraints, it seems better not to include this in the Code. II.e seems designed more for IEEE's benefit than the individual's. Section III, on responsibilities to employers and clients, is not explicit in the 2006 Code and perhaps should be.

b. Nothing new in the 2006 Code not covered in the older Code.

19.13 **a.** ACM Code. The Software Engineering Code (SEC) specifically calls out responsibilities to client and employer. Perhaps ACM Code should as well. In general SEC is more detailed; this has the benefit of covering more ground in more detail but the disadvantage of discouraging professionals from reading the whole code.

b. IEEE Code. SEC specifically calls out responsibilities to client and employer. SEC specifically addresses confidentiality. Both should probably be addressed in IEEE code.

c. AITP Code. SEC refers to the quality of the products of the professional. AITP does not specifically call this out.

CHAPTER 20 SYMMETRIC ENCRYPTION & MESSAGE CONFIDENTIALITY

ANSWERS TO QUESTIONS

20.1 Cryptographic systems are classified along three independent dimensions:
- The type of operations used for transforming plaintext to ciphertext.
- The number of keys used
- The way in which the plaintext is processed.

20.2 The different types of cryptanalysis are:
- Ciphertext only
- Known plaintext
- Chosen plaintext
- Chosen ciphertext
- Chosen text

20.3 An encryption scheme is considered as computationally secure if the ciphertext generated by the scheme meets one or both of the following criteria:
i. The cost of breaking the cipher exceeds the value of the encrypted information
ii. The time required to break the cipher exceeds the useful lifetime of the information.

20.4 A **stream cipher** is one that encrypts a digital data stream one bit or one byte at a time. A **block cipher** is one in which a block of plaintext is treated as a whole and used to produce a ciphertext block of equal length.

20.5 The different block cipher modes of operation are:
- Electronic Code book (ECB)
- Cipher Block Chaining (CBC)
- Cipher Feedback (CFB)
- Output Feedback (OFB)
- Counter (CTR)

20.6 In some modes, the plaintext does not pass through the encryption function, but is XORed with the output of the encryption function. The math works out that for decryption in these cases, the encryption function must also be used.

20.7 With triple encryption, a plaintext block is encrypted by passing it through an encryption algorithm; the result is then passed through the same encryption algorithm again; the result of the second encryption is passed through the same encryption algorithm a third time. Typically, the second stage uses the decryption algorithm rather than the encryption algorithm.

20.8 There is no cryptographic significance to the use of decryption for the second stage. Its only advantage is that it allows users of 3DES to decrypt data encrypted by users of the older single DES by repeating the key.

20.9 The advantages of CTR mode are: hardware efficiency, software efficiency, preprocessing, random access, provable security and simplicity.

20.10 For two parties A and B, key distribution can be achieved in a number of ways, as follows:

1. A can select a key and physically deliver it to B.
2. A third party can select the key and physically deliver it to A and B.
3. If A and B have previously and recently used a key, one party can transmit the new key to the other, encrypted using the old key.
4. If A and B each has an encrypted connection to a third party C, C can deliver a key on the encrypted links to A and B.

20.11 A **session key** is a temporary encryption key used between two principals. A **master key** is a long-lasting key that is used between a key distribution center and a principal for the purpose of encoding the transmission of session keys. Typically, the master keys are distributed by noncryptographic means.

20.12 Security service module is a configuration module for key distribution which performs end-to-end encryption and obtains session keys on behalf of users.

ANSWERS TO PROBLEMS

20.1 Let the input to DES in round *i* be divided into 2 parts: left (L_i) and right (R_i). Define $L'_0 = c(L_0),\ R'_0 = c(R_0)$ and $K'_i = c(K_i)$. We will show that for any stage of DES, $L'_i = c(L_i)$ and $R'_i = c(R_i)$.

- Base Case: When *i* = 1

After the input $L_0 \,||R_0$ is processed through one round of DES with round key K_0: i.e. $DES(L_0, R_0, K_0)$,

$$L_1 = R_0$$
$$R_1 = L_0 \oplus f(R_0, K_0)$$

Similary, for key $K'_0, DES(L'_0, R'_0, K'_0)$,

$$\begin{aligned} L'_1 = R'_0 &= c(R_0) = c(L_0) \\ R'_1 &= L'_0 \oplus f(R'_0, K'_0) \\ &= c(L_0) \oplus f(c(R_0), c(K_0)) \end{aligned} \qquad (1)$$

Since, $f(R_i, K_i)$ uses the bitwise $\oplus$ operation to combine input bits of $\overline{R_i}$ (after expansion) and $\overline{K_i}$ before the permutation in S-boxes, and $\oplus$ operation is associative and commutative,

$$c(r) \oplus c(k) = r \oplus k \qquad (2)$$

Combining, (1) and (2) gives

$$R'_1 = c(L_0) \oplus f(R_0, K_0) = c(R_1)$$

Assume the claim holds for all *i* < *n*

Case when *i* = *n*

For $DES(L_0, R_0, K_{n-1})$,

$$L_n = R_{n-1}$$
$$R_n = L_{n-1} \oplus f(R_{n-1}, K_{n-1})$$

Similarly, $DES(L'_0, R'_0, K'_{n-1})$,

$$\begin{aligned} L'_n = R'_{n-1} &= c(R_{n-1}) \\ R'_n &= L'_{n-1} \oplus f(R'_{n-1}, K'_{n-1}) \\ &= L'_{n-1} \oplus f(c(R_{n-1}), c(K_{n-1})) \\ &= L'_{n-1} \oplus f(R_{n-1}), K_{n-1}) \end{aligned}$$

Therefore, after 16 rounds of DES we get $L'_{16} = c(L_{16})$ and $R'_{16} = c(R_{16})$.

20.2 Because of the key schedule, the round functions used in rounds 9 through 16 are mirror images of the round functions used in rounds 1

through 8. From this fact we see that encryption and decryption are identical. We are given a ciphertext *c*. Let *m*' = *c*. Ask the encryption oracle to encrypt *m*'. The ciphertext returned by the oracle will be the decryption of *c*.

20.3 For $1 \le i \le 128$, take $c_i \in \{0, 1\}^{128}$ to be the string containing a 1 in position i and then zeros elsewhere. Obtain the decryption of these 128 ciphertexts. Let $m_1, m_2, \ldots, m_{128}$ be the corresponding plaintexts. Now, given any ciphertext c which does not consist of all zeros, there is a unique nonempty subset of the c_i's which we can XOR together to obtain c. Let $I(c) \subseteq \{1, 2, \ldots, 128\}$ denote this subset. Observe

$$c = \bigoplus_{i \in I(c)} c_i = \bigoplus_{i \in I(c)} E(m_i) = E\left(\bigoplus_{i \in I(c)} m_i \right)$$

Thus, we obtain the plaintext of c by computing $\bigoplus_{i \in I(c)} m_i$. Let **0** be the all-zero string. Note that **0** = **0** ⊕ **0**. From this we obtain E(**0**) = E(**0** ⊕ **0**) = E(**0**) ⊕ E(**0**) = **0**. Thus, the plaintext of c = **0** is m = **0**. Hence we can decrypt every $c \in \{0, 1\}^{128}$.

20.4 One must select stream cipher because that is more suitable for encrypting and decrypting a stream of data, as is the case most of the times while data is in transit. However, if the data in transit constitutes a file transfer or an e-mail message, block cipher is more suitable.

20.5 **a.** Simply store i, j, and S, which requires 8 + 8 + (256 × 8) = 2064 bits

b. The number of states is $[256! \times 256^2] \approx 2^{1700}$. Therefore, 1700 bits are required.

20.6 **a.** No. For example, suppose Ck is corrupted. The output block Pk+2 depends only on the input blocks Ck+1 and Ck+2.

b. An error in Pk affects Ck. But since Ck is input to the calculation of Ck+1, Ck+1 is affected. This effect carries through indefinitely, so that all ciphertext blocks (except the ones before Ck) are affected. However, at the receiving end, the decryption algorithm restores the correct plaintext for blocks except the one in error. You can show this by writing out the equations for the decryption. Therefore, the error only effects the corresponding decrypted plaintext block.

20.7 Yes, it is possible to perform encryption or decryption operations in parallel on multiple blocks of plaintext or ciphertext in Counter (CTR) mode since there is no chaining.

20.8 a. If the IVs are kept secret, the 3-loop case has more bits to be determined and is therefore more secure than 1-loop for brute force attacks.

b. For software implementations, the performance is equivalent for most measurements. One-loop has two fewer XORs per block. three-loop might benefit from the ability to do a large set of blocks with a single key before switching. The performance difference from choice of mode can be expected to be smaller than the differences induced by normal variation in programming style.

For hardware implementations, three-loop is three times faster than one-loop, because of pipelining. That is: Let P_i be the stream of input plaintext blocks, X_i the output of the first DES, Y_i the output of the second DES and C_i the output of the final DES and therefore the whole system's ciphertext.

In the 1-loop case, we have:

$X_i = DES(XOR(P_i, C_{i-1}))$
$Y_i = DES(X_i)$
$C_i = DES(Y_i)$

[where C_0 is the single IV]

If P_1 is presented at t=0 (where time is measured in units of DES operations), X_1 will be available at t=1, Y_1 at t=2 and C_1 at t=3. At t=1, the first DES is free to do more work, but that work will be:

$X_2 = DES(XOR(P_2, C_1))$

but C_1 is not available until t=3, therefore X_2 can not be available until t=4, Y_2 at t=5 and C_2 at t=6.

In the 3-loop case, we have:

$X_i = DES(XOR(P_i, X_{i-1}))$
$Y_i = DES(XOR(X_i, Y_{i-1}\}))$
$C_i = DES(XOR(Y_i, C_{i-1}))$

[where X_0, Y_0 and C_0 are three independent IVs]

If P_1 is presented at t=0, X_1 is available at t=1. Both X_2 and Y_1 are available at t=4. X_3, Y_2 and C_1 are available at t=3. X_4, Y_3 and C_2 are available at t=4. Therefore, a new ciphertext block is produced every 1 tick, as opposed to every 3 ticks in the single-loop case. This gives the three-loop construct a throughput three times greater than the one-loop construct.

20.9 Instead of CBC [CBC (CBC (X))], use ECB [CBC (CBC (X))]. The final IV was not needed for security. The lack of feedback loop prevents the chosen-ciphertext differential cryptanalysis attack. The extra IVs still become part of a key to be determined during any known plaintext attack.

20.10

Mode	Encrypt	Decrypt
ECB	$C_j = E(K, P_j)$ $j = 1, \ldots, N$	$P_j = D(K, C_j)$ $j = 1, \ldots, N$
CBC	$C_1 = E(K, [P_1 \oplus IV])$ $C_j = E(K, [P_j \oplus C_{j-1}])$ $j = 2, \ldots, N$	$P_1 = D(K, C_1) \oplus IV$ $P_j = D(K, C_j) \oplus C_{j-1}$ $j = 2, \ldots, N$
CFB	$C_1 = P_1 \oplus S_s(E[K, IV])$ $C_j = P_j \oplus S_s(E[K, C_{j-1}])$	$P_1 = C_1 \oplus S_s(E[K, IV])$ $P_j = C_j \oplus S_s(E[K, C_{j-1}])$
OFB	$C_1 = P_1 \oplus S_s(E[K, IV])$ $C_j = P_j \oplus S_s(E(K, [C_{j-1} \oplus P_{j-1}]))$	$P_1 = C_1 \oplus S_s(E[K, IV])$ $P_j = C_j \oplus S_s(E(K, [C_{j-1} \oplus P_{j-1}]))$
CTR	$C_j = P_j \oplus E[K, Counter + j - 1]$	$P_j = C_j \oplus E[K, Counter + j - 1]$

20.11 After decryption, the last byte of the last block is used to determine the amount of padding that must be stripped off. Therefore there must be at least one byte of padding.

20.12 **a.** Assume that the last block of plaintext is only L bytes long, where $L < 2w/8$. The encryption sequence is as follows (The description in RFC 2040 has an error; the description here is correct.):

1. Encrypt the first $(N - 2)$ blocks using the traditional CBC technique.
2. XOR P_{N-1} with previous ciphertext block C_{N-2} to create Y_{N-1}.
3. Encrypt Y_{N-1} to create E_{N-1}.

4. Select the first L bytes of E_{N-1} to create C_N.
5. Pad P_N with zeros at the end and exclusive-OR with E_{N-1} to create Y_N.
6. Encrypt Y_N to create C_{N-1}.

The last two blocks of the ciphertext are C_{N-1} and C_N.

b. $P_{N-1} = C_{N-2} \oplus D(K, [C_N \| X])$
$P_N \| X = (C_N \| 00\ldots0) \oplus D(K, [C_{N-1}])$
P_N = left-hand portion of $(P_N \| X)$
where $\|$ is the concatenation function

20.13 **a.** Assume that the last block (P_N) has j bits. After encrypting the last full block (P_{N-1}), encrypt the ciphertext (C_{N-1}) again, select the leftmost j bits of the encrypted ciphertext, and XOR that with the short block to generate the output ciphertext.

b. While an attacker cannot recover the last plaintext block, he can change it systematically by changing individual bits in the ciphertext. If the last few bits of the plaintext contain essential information, this is a weakness.

20.14 (b+1) plaintext characters are affected. The plaintext character corresponding to the ciphertext character is obviously altered. In addition, the altered ciphertext character enters the shift register and is not removed until all the other characters are processed.

20.15 The CBC mode with an IV of 0 and plaintext blocks D1, D2, . . ., Dn and 64-bit CFB mode with IV = D1 and plaintext blocks D2, D3, . . ., Dn yield the same result.

20.16 It must be ensured that the old key isn't compromised. Otherwise, the attacker can easily obtain all the subsequent keys which are shared between both the parties.

20.17 Yes. The eavesdropper is left with two strings, one sent in each direction, and their XOR is the secret key.

CHAPTER 21 PUBLIC-KEY CRYPTOGRAPHY & MESSAGE AUTHENTICATION

ANSWERS TO QUESTIONS

21.1 The compression function is the fundamental module, or basic building block, of a hash function. The hash function consists of iterated application of the compression function.

21.2 In SHA-1, even if the message length is an exact multiple of block length to be processed in each iteration of the compression function, padding to the original messages is required to ensure that any two distinct messages would create different hash values. Without a reversible padding scheme, it is easy to construct collisions for the hash function.

21.3 For HMAC to be provably secure in terms of collision-resistance, the minimum requirement is that underlying hash function is collision-resistant. If underlying hash function is not collision-resistant, then replace this with a secure hash function.

21.4 For any given code h, it is computationally infeasible to find x such that $H(x) = h$. A hash function with this property is referred to as **one-way**. This definition appeared in Chapter 2.

21.5 Two parties each create a public-key, private-key pair and communicate the public key to the other party. The keys are designed in such a way that both sides can calculate the same unique secret key based on each side's private key and the other side's public key.

ANSWERS TO PROBLEMS

21.1 a. Yes. The XOR function is simply a vertical parity check. If there is an odd number of errors, then there must be at least one column that contains an odd number of errors, and the parity bit for that column will detect the error. Note that the RXOR function also catches all errors caused by an odd number of error bits. Each RXOR bit is a function of a unique "spiral" of bits in the block of

data. If there is an odd number of errors, then there must be at least one spiral that contains an odd number of errors, and the parity bit for that spiral will detect the error.

b. No. The checksum will fail to detect an even number of errors when both the XOR and RXOR functions fail. In order for both to fail, the pattern of error bits must be at intersection points between parity spirals and parity columns such that there is an even number of error bits in each parity column and an even number of error bits in each spiral.

c. It is too simple to be used as a secure hash function; finding multiple messages with the same hash function would be too easy.

21.2 **a.** It satisfies the properties 1 through 3, but does not satisfy the remaining properties. For example, for property 4, a message consisting of the value h satisfies $H(h)=h$. For property 5, take any message M and add reverse the sequence of decimal digits to construct another message; it will have the same hash value.

b. It satisfies the properties 1 through 3. Properties 4 is also satisfied if n is a large composite number, because taking square roots modulo such an integer n is considered to be infeasible. Properties 5 and 6 are not satisfied because $(-M)$ will have the same value as M.

c. 45

21.3 Yes, there is a similarity between these two operations. Both these operations result in flipping one-half of the bits of K. However, it must be noted that a different set of bits are flipped by each operation.

21.4 The opponent has the two-block message B1, B2 and its hash RSAH(B1, B2). The following attack will work. Choose an arbitrary C1 and choose C2 such that:

$$C2 = RSA(C1) \oplus RSA(B1) \oplus B2$$

then

$$\begin{aligned} RSA(C1) \oplus C2 &= RSA(C1) \oplus RSA(C1) \oplus RSA(B1) \oplus B2 \\ &= RSA(B1) \oplus B2 \end{aligned}$$

so $$\begin{aligned} RSAH(C1, C2) &= RSA[RSA(C1) \oplus C2)] = RSA[RSA(B1) \oplus B2] \\ &= RSAH(B1, B2) \end{aligned}$$

21.5 **a.** Two quantities are precomputed:

$$f(IV, (K^+ \oplus ipad))$$
$$f(IV, (K^+ \oplus opad))$$

where f(cv, block) is the compression function for the hash function, which takes as arguments a chaining variable of n bits and a block of b bits and produces a chaining variable of n bits. These quantities

only need to be computed initially and every time the key changes. In effect, the precomputed quantities substitute for the initial value (IV) in the hash function. With this implementation, only one additional instance of the compression function is added to the processing normally produced by the hash function.

b. This is a more efficient implementation. This more efficient implementation is especially worthwhile if most of the messages for which a MAC is computed are short.

21.6 a. n = 403; ø(n) = 360; d = 19
Encryption:
C = Me mod n = 219 mod 403
Therefore, C = 388
Decryption:
M = Cd mod n = 38819 mod 403
= 38816 × 38812 × 3881 mod 403
= 2

b. n = 341; ø(n) = 300; d = 43
Encryption:
C = Me mod n = 47 mod 341
Therefore, C = 16
Decryption:
M = Cd mod n = 1643 mod 341
= 1632 × 168 × 162 × 161 mod 341
= 4

c. n = 51; ø(n) = 32; d = 13
Encryption:
C = Me mod n = 55 mod 51
Therefore, C = 14
Decryption:
M = Cd mod n = 1413 mod 51
= 148 × 144 × 141 mod 51
= 5

d. n = 85; ø(n) = 64; d = 55
Encryption:
C = Me mod n = 67 mod 85
Therefore, C = 31
Decryption:
M = Cd mod n = 3155 mod 85
= 3132 × 3116 × 314 × 312 × 311 mod 85
= 6

e. n = 119; ø(n) = 96; d = 53
Encryption:
C = Me mod n = 329 mod 119
Therefore, C = 12
Decryption:
M = Cd mod n = 1253 mod 119

$= 1232 \times 1216 \times 124 \times 121 \bmod 119$
$= 3$

21.7 M = 3

21.8 d = 983

21.9 In RSA cryptosystem, if one can compute $\phi(n)$, then using Extended Euclidean algorithm, one can compute secret key d such that $ed \equiv 1 \bmod \phi(n)$.

Observe that $n = pq$ and $\phi(n) = (p - 1)(q - 1) = pq - p - q + 1 = n - (p + q) + 1$. Thus, $(p + q) = (n + 1) - \phi(i)$.

Now from high school algebra, we know that $(p - q)^2 = (p + q)^2 - 4pq = ((n + 1) - \phi(n))^2 - 4n$. Solving $(p + q)$ and $(p - q)$ for p and q will yield the required result.

21.10 Yes.

21.11 Consider a set of alphabetic characters {A, B, …, Z}. The corresponding integers, representing the position of each alphabetic character in the alphabet, form a set of message block values SM = {0, 1, 2, …, 25}. The set of corresponding ciphertext block values SC = $\{0^e \bmod N, 1^e \bmod N, \ldots, 25^e \bmod N\}$, and can be computed by everybody with the knowledge of the public key of Bob.

Thus, the most efficient attack against the scheme described in the problem is to compute $M^e \bmod N$ for all possible values of M, then create a look-up table with a ciphertext as an index, and the corresponding plaintext as a value of the appropriate location in the table.

21.12 **a.** $X_A = 3$
b. K = 6

CHAPTER 22 INTERNET SECURITY PROTOCOLS & STANDARDS

ANSWERS TO QUESTIONS

22.1 The default algorithms used for signing S/MIME messages are:
- Digital Signature Standard (DSS) and
- Secure Hash Algorithm, revision 1 (SHA-1).

22.2 R64 converts a raw 8-bit binary stream to a stream of printable ASCII characters. Each group of three octets of binary data is mapped into four ASCII characters.

22.3 When S/MIME is used, at least part of the block to be transmitted is encrypted. If only the signature service is used, then the message digest is encrypted (with the sender's private key). If the confidentiality service is used, the message plus signature (if present) are encrypted (with a one-time symmetric key). Thus, part or all of the resulting block consists of a stream of arbitrary 8-bit octets. However, many electronic mail systems only permit the use of blocks consisting of ASCII text.

22.4 DomainKeys Identified Mail (DKIM) is a specification for cryptographically signing e-mail messages, permitting a signing domain to claim responsibility for a message in the mail stream.

22.5 The following elements - URL of the requested document, contents of the document, contents of the browser forms (filled in by browser user), cookies sent from browser to server and from server to browser and contents of the HTTP header – are encrypted in a https connection.

22.6 **Connection:** A connection is a transport (in the OSI layering model definition) that provides a suitable type of service. For SSL, such connections are peer-to-peer relationships. The connections are transient. Every connection is associated with one session. **Session:** An SSL session is an association between a client and a server. Sessions are created by the Handshake Protocol. Sessions define a set of cryptographic security parameters, which can be shared among

multiple connections. Sessions are used to avoid the expensive negotiation of new security parameters for each connection.

22.7 A) Attacks on Handshake Protocol
B) Attacks on the record and application data protocols
C) Attacks on the PKI
D) Other attacks such as DoS attacks

22.8 The following are the four categories of SSL/TLS attacks:

- Attacks on the Handshake Protocol.
- Attacks on the record and application data protocols
- Attacks on the PKI
- Other attacks

22.9 The following are the three levels of awareness of a connection in HTTPS:

- HTTP level
- TLS level
- TCP / transport level

22.10 Transport mode provides protection for upper layer protocols, i.e., to the payload of an IP packet. Examples include a TCP or UDP segment, both of which operate directly above IP in a host protocol stack. Typically, transport mode is used for end-to-end communication between two hosts. Tunnel mode provides protection to the entire IP packet. To achieve this, after the ESP fields are added to the IP packet, the entire packet plus security fields are treated as the payload of new outer IP packet with a new outer IP header. Tunnel mode is used when one or both ends of a security association are a security gateway, such as a firewall or router that implements IPsec.

22.11 **1.** an authentication-only function referred to as Authentication Header (AH); **2.** a combined authentication/encryption function called Encapsulating Security Payload (ESP).

ANSWERS TO PROBLEMS

22.1 The change cipher spec protocol exists to signal transitions in ciphering strategies, and can be sent independent of the complete handshake protocol exchange.

22.2 **a. Man-in-the-Middle Attack:** This is prevented by the use of public-key certificates to authenticate the correspondents.
b. Password Sniffing: User data is encrypted.

c. **IP Spoofing:** The spoofer must be in possession of the secret key as well as the forged IP address.
d. **IP Hijacking:** Again, encryption protects against this attack.
e. **SYN Flooding:** SSL provides no protection against this attack.

22.3 The three levels of awareness are: one at the HTTP level, second at the TLS/SSL level and the third at TCP level.

A TLS request to establish a connection begins with the establishment of a TCP connection between the TCP entity on the client side and the TCP entity on the server side.

22.4 Inbound processing proceeds as follows when a packet is received:
1. If the received packet falls within the window and is new, the MAC is checked. If the packet is authenticated, the corresponding slot in the window is marked.
2. If the received packet is to the right of the window and is new, the MAC is checked. If the packet is authenticated, the window is advanced so that this sequence number is the right edge of the window, and the corresponding slot in the window is marked.
3. If the received packet is to the left of the window, or if authentication fails, the packet is discarded; this is an auditable event.

22.5 The first mode is called **transport mode**, which provides protection primarily for upper-layer protocols. That is, transport mode protection extends to the payload of an IP packet. Examples include a TCP or UDP segment or an ICMP packet, all of which operate directly above IP in a host protocol stack. Typically, transport mode is used for end-to-end communication between two hosts (e.g., a client and a server, or two workstations). When a host runs AH or ESP over IPv4, the payload is the data that normally follow the IP header. For IPv6, the payload is the data that normally follow both the IP header and any IPv6 extensions headers that are present, with the possible exception of the destination options header, which may be included in the protection. ESP in transport mode encrypts and optionally authenticates the IP payload but not the IP header. AH in transport mode authenticates the IP payload and selected portions of the IP header.
The second mode is called **tunnel mode**, which provides protection to the entire IP packet. To achieve this, after the AH or ESP fields are added to the IP packet, the entire packet plus security fields is treated as the payload of new "outer" IP packet with a new outer IP header. The entire original, or inner, packet travels through a "tunnel" from one point of an IP network to another; no routers along the way are able to examine the inner IP header. Because the original packet is encapsulated, the new, larger packet may have totally different source and destination addresses, adding to the security. Tunnel mode is used

when one or both ends of an SA are a security gateway, such as a firewall or router that implements IPSec. With tunnel mode, a number of hosts on networks behind firewalls may engage in secure communications without implementing IPSec. The unprotected packets generated by such hosts are tunneled through external networks by tunnel mode SAs set up by the IPSec software in the firewall or secure router at the boundary of the local network.

22.6 The step by step procedure for signing the S/MIME messages is as explained below:

a. The message which is to be sent is first mapped into a fixed-length code of 160 bits, using SHA-1. The 160-bit message digest is unique for this message.

b. S/MIME then encrypts the digest using DSS and the sender's private DSS key. The result is the digital signature, which is attached to the message.

c. Anyone who gets this message can re-compute the message digest and then decrypt the signature using DSS and the sender's public DSS key.

d. If the message digest in the signature matches the message digest that was calculated, then the signature is valid.

22.7 The **quoted-printable** transfer encoding is useful when the data consist largely of octets that correspond to printable ASCII characters. The **base64 transfer encoding**, also known as radix-64 encoding, is a common one for encoding arbitrary binary data in such a way as to be invulnerable to the processing by mail transport programs. This technique maps arbitrary binary input into printable character output.

CHAPTER 23 INTERNET AUTHENTICATION APPLICATIONS

ANSWERS TO QUESTIONS

23.1 The ticket carries: user's ID, the server's ID, a timestamp, a lifetime after which the ticket is invalid, and a copy of the session key sent in the outer message to the client. Note that the entire ticket is encrypted and no one can tamper with the ticket.

23.2 A full-service Kerberos environment consists of a Kerberos server, a number of clients, and a number of application servers. Moreover, it also requires that: the Kerberos server must have the user ID and password of all participating users in its database and it must share a secret key with each server.

23.3 An authentication server (AS) has a list of passwords of all the clients and stores the same in a centralized database. The user can log in to the AS for identity verification at any point. Once the AS has verified the user's identity, it can pass this information to an application server, which then accepts service requests from the client.

23.4 The authentication server (AS) shares a unique secret key with each server. These keys are already distributed physically or in some other secure manner. This enables the AS to send messages to application servers in a secure fashion. To begin with, the user logs on to a workstation and requests access to a particular server. The client process representing the user sends a message to the AS that includes the user's ID and a request for what is known as a ticket-granting ticket (TGT). The AS checks its database to find the password of this user. Then the AS responds with a TGT and a one-time encryption key, known as a session key, both encrypted using the user's password as the encryption key. When this message arrives at the client, the client prompts the user for his or her password, generates the key, and attempts to decrypt the incoming message. If the correct password has been supplied, the ticket and session key are successfully recovered.

23.5 One important extension, in the "Basic Constraints" set specifies whether the certificate is that of a CA or not. A CA certificate is used only to sign other certificates. Otherwise the certificate belongs to an "end-user" (or "end-entity"), and may be used for verifying server or client identities, signing or encrypting email or other content, signing executable code, or other uses in applications. The usage of any certificate's key can be restricted by including the "Key Usage" and "Extended Key Usage" extensions that specify a set of approved uses. "End-user" certificates are not permitted to sign other certificates, apart from the special case of proxy-certificates.

23.6 Typically, the trusted third party that signs certificates is a **certificate authority** (CA) that is trusted by the user community, such as a government agency, financial institution, telecommunications company, or other trusted peak organization. A user can present his or her public key to the authority in a secure manner and obtain a certificate. The user can then publish the certificate, or send it to others. Anyone needing this user's public key can obtain the certificate and verify that it is valid by way of the attached trusted signature, provided they can verify the CA's public key.

23.7 X.509 certificate variants include:

- **Conventional (long-lived) certificates**: traditional CA and "end user" certificates, linking an identity with a public key, which are typically issued for validity periods of months to years.
- **Short-lived certificates**: are used to provide authentication for applications such as grid computing, while avoiding some of the overheads and limitations of conventional certificates, with validity periods of just hours to days, which limits the period of misuse if compromised.
- **Proxy certificates**: are widely used to provide authentication for applications such as grid computing, while addressing some of the limitations of short-lived certificates. They are identified by the presence of the "proxy certificate" extension. They allow an "end user" certificate to sign another certificate, which must be an extension of their existing certificate.
- **Attribute certificates**: which use a different certificate format, link a user's identity to a set of attributes that are typically used for authorization and access control.

23.8 The X.509 standard defines a certificate revocation list (CRL), signed by the issuer. When an application receives a certificate, the X.509 standard states it should determine whether it has been revoked, by checking against the current CRL for its issuing CA. However, due to the overheads in retrieving and storing these lists, very few applications actually do this. A more practical alternative is to use the Online Certificate Status Protocol (OCSP) to query the CA as to

whether a specific certificate is valid. This lightweight protocol is increasingly used, including in most common web browsers.

23.9 Short-lived certificates are used to provide authentication for applications such as grid computing, while avoiding some of the overheads and limitations of conventional certificates. They have validity periods of hours to days, which limits the period of misuse if compromised.

23.10 Current X.509 PKI implementations came with a large list of CAs and their public keys, known as a "trust store." These CAs usually either directly sign "end-user" certificates or sign a small number of Intermediate-CAs that in turn sign "end-user" certificates. Thus all the PKI hierarchies are very small, and all are equally trusted. Users and servers that want an automatically verified certificate must acquire it from one of these CAs. Alternatively they can use either a "self-signed" certificate or a certificate signed by some other CA. However, in both these cases, such certificates will initially be recognized as "untrusted" and the user presented with stark warnings about accepting such certificates, even if they are actually legitimate.

23.11 Some key problems with current public key infrastructure implementations include:

- the reliance on the user to make an informed decision when there is a problem verifying a certificate.
- the assumption that all of the CAs in the "trust store" are equally trusted, equally well managed, and apply equivalent policies.
- that different implementations, in the various web browsers and operating systems, use different "trust stores," and hence present different security views to users.

23.12 PKIX key elements are:

End entity: A generic term used to denote end users, devices (e.g., servers, routers), or any other entity that can be identified in the subject field of a public-key certificate. End entities typically consume and/or support PKI-related services.

Certification authority (CA): The issuer of certificates and (usually) certificate revocation lists (CRLs). It may also support a variety of administrative functions, although these are often delegated to one or more registration authorities.

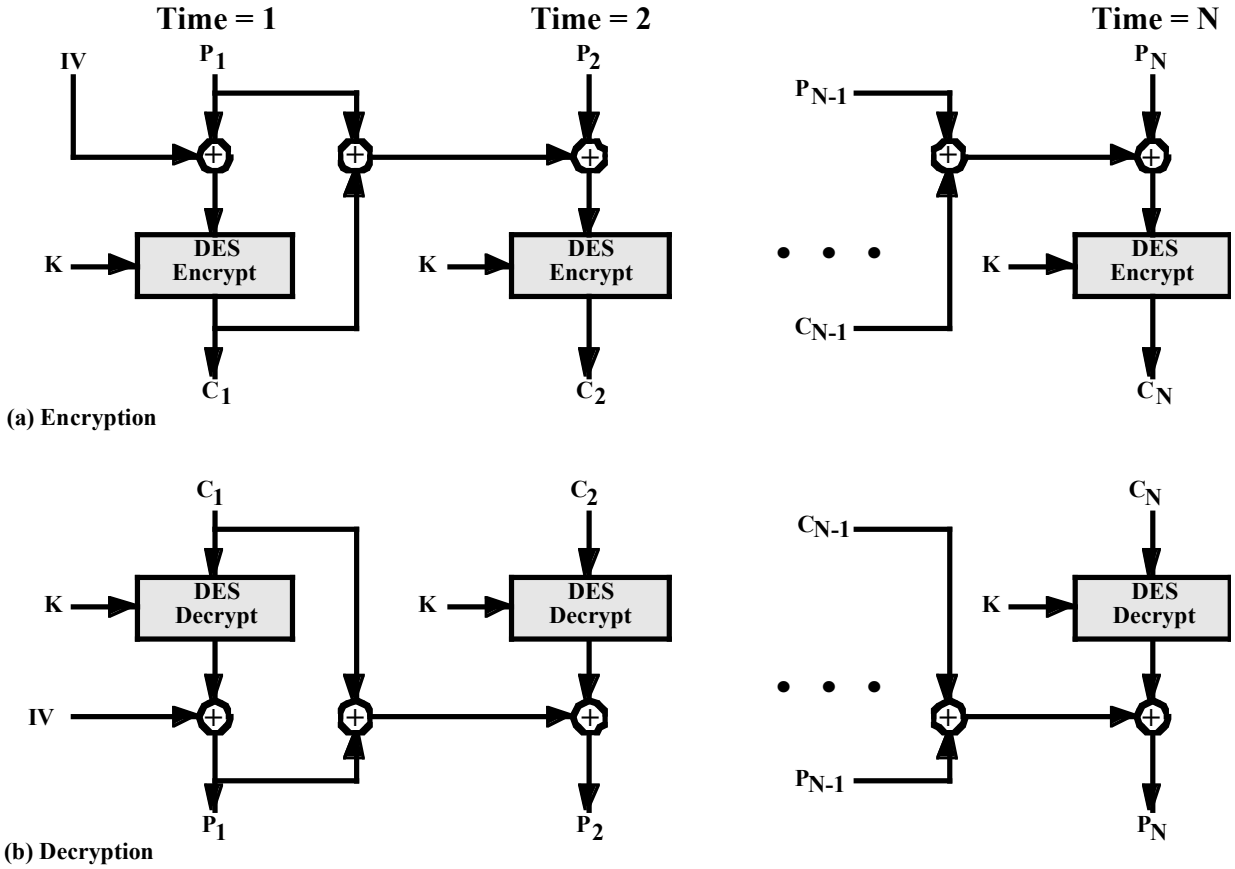
Registration authority (RA): An optional component that can assume a number of administrative functions from the CA. The RA is often associated with the end entity registration process but can assist in a number of other areas as well.

CRL issuer: An optional component that a CA can delegate to publish CRLs.

Repository: A generic term used to denote any method for storing certificates and CRLs so that they can be retrieved by end entities.

ANSWERS TO PROBLEMS

23.1 a.



b. On decryption, each ciphertext block is passed through the decryption algorithm. Then the output is XORed with the preceding ciphertext block and the preceding plaintext block. We can demonstrate that this scheme works, as follows:

$$D(K, C_n) = D(K, E(K, [C_{n-1} \oplus P_{n-1} \oplus P_n]))$$
$$D(K, C_n) = C_{n-1} \oplus P_{n-1} \oplus P_n$$
$$C_{n-1} \oplus P_{n-1} \oplus D(K, C_n) = P_n$$

c. An error in C_1 affects P_1 because the encryption of C_1 is XORed with IV to produce P_1. Both C_1 and P_1 affect P_2, which is the XOR of the encryption of C_2 with the XOR of C_1 and P_1. Beyond that, P_{N-1} is one of the XORed inputs to forming P_N.

23.2 Let us consider the case of the interchange of C_1 and C_2. The argument will be the same for any other adjacent pair of ciphertext blocks. First, if C_1 and C_2 arrive in the proper order:

$P_1 = E[K, C_1] \oplus IV$
$P_2 = E[K, C_2] \oplus C_1 \oplus P_1 = E[K, C_2] \oplus C_1 \oplus E[K, C_1] \oplus IV$
$P_3 = E[K, C_3] \oplus C_2 \oplus P_2 = E[K, C_3] \oplus C_2 \oplus E[K, C_2] \oplus C_1 \oplus E[K, C_1] \oplus IV$

Now suppose that C_1 and C_2 arrive in the reverse order. Let us refer to the decrypted blocks as Q_i.

$Q_1 = E[K, C_2] \oplus IV$
$Q_2 = E[K, C_1] \oplus C_2 \oplus Q_1 = E[K, C_1] \oplus C_2 \oplus E[K, C_2] \oplus IV$
$Q_3 = E[K, C_3] \oplus C_1 \oplus Q_2 = E[K, C_3] \oplus C_1 \oplus E[K, C_1] \oplus C_2 \oplus E[K, C_2] \oplus IV$

The result is that $Q_1 \neq P_1$; $Q_2 \neq P_2$; but $Q_3 = P_3$. Subsequent blocks are clearly unaffected.

23.3 Given the X.509 certificate shown:

a. key elements are:

- owner's name (Subject, Verisign Digital ID class 1 for John Doe):

```
Subject: O=VeriSign, Inc.,
OU=VeriSign Trust Network,
OU=Persona Not Validated,
OU=Digital ID Class 1 - Netscape
CN=John Doe/Email=john.doe@adfa.edu.au
```

- public key (RSA key with 512 bit modulus as shown):

```
Subject Public Key Info:
  Public Key Algorithm: rsaEncryption
  RSA Public Key: (512 bit)
    Modulus (512 bit):
      00:98:f2:89:c4:48:e1:3b:2c:c5:d1:48:67:80:53:
      d8:eb:4d:4f:ac:31:a9:fd:11:68:94:ba:44:d8:48:
      46:0d:fc:5c:6d:89:47:3f:9f:d0:c0:6d:3e:9a:8e:
      ec:82:21:48:9b:b9:78:cf:aa:09:61:92:f6:d1:cf:
      45:ca:ea:8f:df
    Exponent: 65537 (0x10001)
```

- validity dates (Jan 13 to Mar 13 2000):

```
Validity
  Not Before: Jan 13 00:00:00 2000 GMT
  Not After : Mar 13 23:59:59 2000 GMT
```

- name of the CA that signed it (Issuer, Verisign Inc):

```
Issuer: O=VeriSign, Inc.,
  OU=VeriSign Trust Network,
  CN=VeriSign Class 1 CA Individual - Persona Not Validated
```

- type (MD5 with RSA) and value of signature:

```
  Signature Algorithm: md5WithRSAEncryption
     5a:71:77:c2:ce:82:26:02:45:41:a5:11:68:d6:99:f0:4c:ce:
     7a:ce:80:44:f4:a3:1a:72:43:e9:dc:e1:1a:9b:ec:64:f7:ff:
     21:f2:29:89:d6:61:e5:39:bd:04:e7:e5:3d:7b:14:46:d6:eb:
     8e:37:b0:cb:ed:38:35:81:1f:40:57:57:58:a5:c0:64:ef:55:
```

```
59:c0:79:75:7a:54:47:6a:37:b2:6c:23:6b:57:4d:62:2f:94:
d3:aa:69:9d:3d:64:43:61:a7:a3:e0:b8:09:ac:94:9b:23:38:
e8:1b:0f:e5:1b:6e:e2:fa:32:86:f0:c4:0b:ed:89:d9:16:e4:
a7:77
```

b. it is an end-user certificate, as it has:

```
X509v3 Basic Constraints:
  CA:FALSE
```

this would have to be "`CA:TRUE`" for a CA certificate.

c. the certificate is not valid as it's validity dates are in the past.

d. the other obvious problem with the algorithms used in this certificate is the use of MD5 in the signature, since research advances in creating MD5 collisions has led to the development of several techniques for forging new certificates for different identities that have the same hash, and hence can reuse the same signature, as an existing valid certificate. Any still valid certificates using MD5 should be revoked and replaced as soon as possible.

23.4 There is no single answer for this problem, as it depends on the site, and it's X.509 certificate. To answer the questions as for 23.3, you would view the same elements of the certificate as listed above. Note that this will be an end-user certificate, as in 23.3.

23.5 There is no single answer for this problem, as it depends on the authority selected, and it's X.509 certificate. To answer the questions as for 23.3, you would view the same elements of the certificate as listed above. Note that this will be a CA certificate, i.e. have "`CA:TRUE`".

CHAPTER 24 WIRELESS NETWORK SECURITY

ANSWERS TO QUESTIONS

24.1 Basic service set.

24.2 Two or more basic service sets interconnected by a distribution system.

24.3 **Association:** Establishes an initial association between a station and an AP. **Authentication:** Used to establish the identity of stations to each other. **Deauthentication:** This service is invoked whenever an existing authentication is to be terminated. **Disassociation:** A notification from either a station or an AP that an existing association is terminated. A station should give this notification before leaving an ESS or shutting down. **Distribution:** used by stations to exchange MAC frames when the frame must traverse the DS to get from a station in one BSS to a station in another BSS. **Integration:** enables transfer of data between a station on an IEEE 802.11 LAN and a station on an integrated IEEE 802.x LAN. **MSDU delivery:** delivery of MAC service data units. **Privacy:** Used to prevent the contents of messages from being read by other than the intended recipient. **Reassocation:** Enables an established association to be transferred from one AP to another, allowing a mobile station to move from one BSS to another.

24.4 The two main assumptions that form the basis of security policy for mobile devices are: (i) mobile device may be stolen and (ii) mobile device can be accessed by a malicious party.

24.5 The following are the seven major security concerns for mobile devices:

- Lack of physical security controls
- Use of untrusted mobile devices
- Use of untrusted networks
- Use of applications created by unknown parties
- Interaction with other systems
- Use of untrusted content

- Use of location services

24.6 The pseudorandom function of IEEE 802.11i scheme uses HMAC-SHA-1 to generate pseudorandom streams. The IEEE 802.11i pseudorandom function takes four parameters as input and produces the pseudorandom stream of required number of bits. The four input parameters are as: a secret key, a text string specific to application, some data specific to each case and the length of pseudorandom stream.

Some of the use-cases for pseudorandom function are: to generate nonce, to expand pairwise keys, and to generate the GTK.

24.7 **Discovery:** An AP uses messages called Beacons and Probe Responses to advertise its IEEE 802.11i security policy. The STA uses these to identify an AP for a WLAN with which it wishes to communicate. The STA associates with the AP, which it uses to select the cipher suite and authentication mechanism when the Beacons and Probe Responses present a choice.
Authentication: During this phase, the STA and AS prove their identities to each other. The AP blocks non-authentication traffic between the STA and AS until the authentication transaction is successful. The AP does not participate in the authentication transaction other than forwarding traffic between the STA and AS.
Key generation and distribution: The AP and the STA perform several operations that cause cryptographic keys to be generated and placed on the AP and the STA. Frames are exchanged between the AP and STA only
Protected data transfer: Frames are exchanged between the STA and the end station through the AP. As denoted by the shading and the encryption module icon, secure data transfer occurs between the STA and the AP only; security is not provided end-to-end.
Connection termination: The AP and STA exchange frames. During this phase, the secure connection is torn down and the connection is restored to the original state.

24.8 TKIP is designed to require only software changes to devices that are implemented with the older wireless LAN security approach called Wired Equivalent Privacy (WEP).

ANSWERS TO PROBLEMS

24.1 **a.** This scheme is extremely simple and easy to implement. It does protect against very simple attacks using an off-the-shelf Wi-Fi LAN card, and against accidental connection to the wrong network.

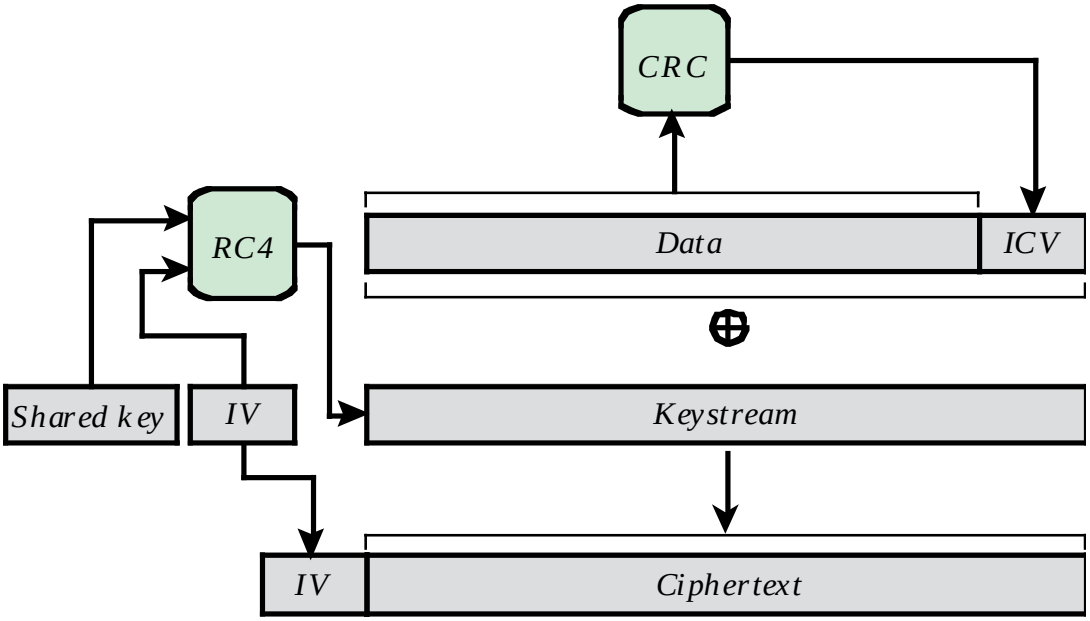
b. This scheme depends on all parties behaving honestly. The scheme does not protect against MAC address forgery.

24.2 **a.** Because the AP remembers the random number previously sent, it can check whether the result sent back was encrypted with the correct key; the STA must know the key in order to encrypt the random value successfully.

b. This scheme does nothing to prove to the STA that the AP knows the key, so authentication is only one way.

c. If an attacker is eavesdropping, this scheme provides the attacker with a plaintext-ciphertext pair to use in cryptanalysis.

24.3 a.

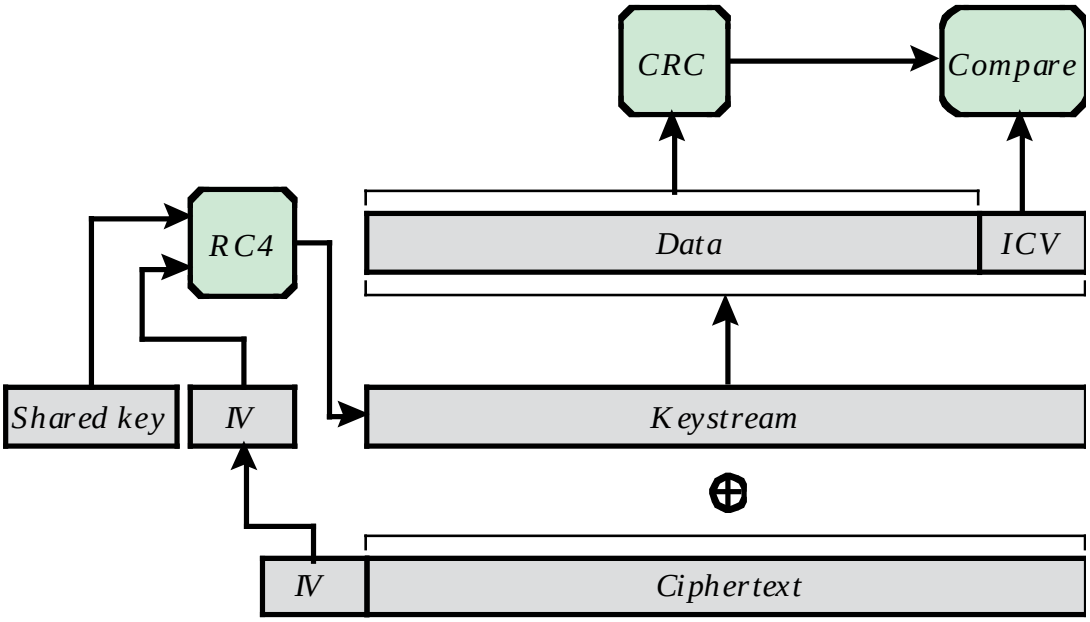


b. 1. The IV value, which is received in plaintext, is concatenated with the WEP key shared by transmitter and receiver to form the seed, or key input, to RC4.

2. The ciphertext portion of the received MPDU is decrypted using RC4 to recover the Data block and the ICV.

3. The ICV is computed over the plaintext received Data block and compared to the received plaintext ICV to authenticate the Data block.

c.



24.4 Because WEP works by XORing the data to get the ciphertext, bit flipping survives the encryption process. Flipping a bit in the plaintext always flips the same bit in the ciphertext and vice versa.

CHAPTER 25 TRUSTED COMPUTING AND MULTILEVEL SECURITY

ANSWERS TO QUESTIONS

25.1 In most security models, each subject and each object is assigned a **security class**. In the simplest formulation, security classes form a strict hierarchy and are referred to as **security levels.** A subject is said to have a **security clearance** of a given level; an object is said to have a **security classification** of a given level.

25.2 **no read up:** A subject can only read an object of less or equal security level. This is referred to in the literature as the simple security property (ss-property).
no write down: A subject can only write into an object of greater or equal security level. This is referred to in the literature as the *-property.
ds-property: An individual (or role) may grant to another individual (or role) access to a document based on the owner's discretion, constrained by the MAC rules. Thus, a subject can exercise only accesses for which it has the necessary authorization and which satisfy the MAC rules.

25.3 The ds-property.

25.4 The BLP model deals with confidentiality and is concerned with unauthorized disclosure of information. The Biba models deals with integrity and is concerned with the unauthorized modification of data.

25.5 **Simple integrity:** A subject can modify an object only if the integrity level of the subject dominates the integrity level of the object: $I(S) \geq I(O)$.
Integrity confinement: A subject can read on object only if the integrity level of the subject is dominated by the integrity level of the object: $I(S) \leq I(O)$.
Invocation property: A subject can invoke another subject only if the integrity level of the first subject dominates the integrity level of the second subject: $I(S1) \geq I(S2)$.

25.6 **Certification rules** are security policy restrictions on the behavior of Integrity Verification Procedures and Transformation Procedures. **Enforcement rules** are built-in system security mechanisms that achieve the objectives of the certification rules.

25.7 The Chinese wall is a logical barrier that prevents a subject that accesses data from one side of the wall from accessing data on the other side.

25.8 **No read up:** A subject can only read an object of less or equal security level. **No write down:** A subject can only write into an object of greater or equal security level.

25.9 **Complete mediation:** The security rules are enforced on every access, not just, for example, when a file is opened. **Isolation:** The reference monitor and database are protected from unauthorized modification. **Verifiability:** The reference monitor's correctness must be provable. That is, it must be possible to demonstrate mathematically that the reference monitor enforces the security rules and provides complete mediation and isolation.

25.10 Roles can be defined by type of access and clearance level.

25.11 **Entire database:** This simple approach is easily accomplished on an MLS platform. An entire database, such as a financial or personnel database, could be classified as confidential or restricted and maintained on a server with other files.

Individual tables (relations): For some applications, it is appropriate to assign classification at the table level. In the example of Figure 25.10a, two levels of classification are defined: unrestricted (U) and restricted (R). The Employee table contains sensitive salary information and is classified restricted, while the Department table is unrestricted. This level of granularity is relatively easy to implement and enforce.

Individual columns (attributes): A security administrator may choose to determine classification on the basis of attributes, so that selected columns are classified. In the example of Figure 25.10b, the administrator determines that salary information and the identity of department managers is restricted information.

Individual rows (tuples): In other circumstances, it may make sense to assign classification levels on the basis of individual rows that match certain properties. In the example of Figure 25.10c, all rows in the Department table that contain information relating to the Accounts Department (Dept. ID = 4), and all rows in the Employee Table for which the Salary is greater than 50K are restricted.

Individual elements: The most difficult scheme to implement and manage is one in which individual elements may be selectively

classified. In the example of Figure 25.10d, salary information and the identity of the manager of the Accounts Department are restricted.

25.12 In a database, insert a new row at the lower level without modifying the existing row at the higher level. This is known as **polyinstantiation**. This avoids the inference and data integrity problems but creates a database with conflicting entries

25.13 **Authenticated boot service:** The authenticated boot service is responsible for booting the entire operating system in stages and assuring that each portion of the OS, as it is loaded, is a version that is approved for use.
Certification service: Once a configuration is achieved and logged by the TPM, the TPM can certify the configuration to other parties. The TPM can produce a digital certificate by signing a formatted description of the configuration information using the TPM's private key. Thus, another user, either a local user or a remote system, can have confidence that an unaltered configuration is in use.
Encryption service: The encryption service enables the encryption of data in such a way that the data can be decrypted only by a certain machine and only if that machine is in a certain configuration.

25.14 The aim of these standards is to provide greater confidence in the security of IT products as a result of formal actions taken during the process of developing, evaluating, and operating these products.

25.15 One of the security assurance requirements is that security functionality is not compromised during product delivery. Thus, security functionality is one of the concerns of security assurance.

25.16 •Sponsor: Usually either the customer or the vendor of a product for which evaluation is required. Sponsors determine the security target that the product has to satisfy.
•Developer: Has to provide suitable evidence on the processes used to design, implement, and test the product to enable its evaluation.
•Evaluator: Performs the technical evaluation work, using the evidence supplied by the developers, and additional testing of the product, to confirm that it satisfies the functional and assurance requirements specified in the security target. In many countries, the task of evaluating products against a trusted computing standard is delegated to one or more endorsed commercial suppliers.
•Certifier: The government agency that monitors the evaluation process and subsequently certifies that a product as been successfully evaluated. Cookies generally manage a register of evaluated products, which can be consulted by customers.

25.17 **1.** Preparation: Involves the initial contact between the sponsor and developers of a product, and the evaluators who will assess it. It will confirm that the sponsor and developers are adequately prepared to conduct the evaluation and will include a review of the security target and possibly other evaluation deliverables. It concludes with a list of evaluation deliverables and acceptance of the overall project costing and schedule.
2. Conduct of evaluation: A structured and formal process in which the evaluators conduct a series of activities specified by the CC. These include reviewing the deliverables provided by the sponsor and developers, and other tests of the product, to confirm it satisfies the security target. During this process, problems may be identified in the product, which are reported back to the developers for correction.
3. Conclusion: The evaluators provide the final evaluation technical report to the certifiers for acceptance. The certifiers use this report, which may contain confidential information, to validate the evaluation process and to prepare a public certification report. The certification report is then listed on the relevant register of evaluated products.

ANSWERS TO PROBLEMS

25.1 The purpose of the "no write down" rule, or *-property is to address the problem of Trojan horse software. With the *-property, information cannot be compromised through the use of a Trojan horse. Under this property, a program operating on behalf of one user cannot be used to pass information to any user having a lower or disjoint access class.

25.2 An append function only requires the ability to update the object without observing (reading) the object. The write function requires the ability to read as well.

25.3 **a.** The set b defines the current accesses. As long as these accesses satisfy the model properties, security is enforced. That is all that is strictly required.
b. The current accesses are determined in part by the permissions defined in the access matrix M. It would be difficult to properly implement the security policy without enforcing the restrictions on M.

25.4 Figure 25.2a: Rule 7 (create object), used by both Dirk and Carla.
Figure 25.2b: Dirk reads f2 (Rule 1). Dirk creates file (Rule 7).
Figure 25.2.c: Dirk creates file (Rule 7)
Figure 25.2d: Dirk downgrades a classification. This is done by a security administrator, outside the scope of the rules.

Figure 25.2e: Carla creates a file (Rule 7) and writes to the file (Rule 1).

25.5 They reflect the role ability to read down and write up.

25.6 **a.** *allow* (s, *repository*, *browse*(s)) iff label (s) ≥ class (repository)
allow (s, *repository*, *insert*(s)) iff label (s) ≤ class (repository)

b. In the initial state, subjects cannot browse information unless their label is MAX which is equal to class (repository) and hence no read up (NRU) is satisfied (first condition of 25.6a). Also, in the initial state, all subjects can insert information but since class (repository) is MAX, subject labels will always be less than or equal to the repository label and hence no write down (NWD) is satisfied (second condition of 25.6b).
Assuming NRU and NWD are met in the current state, it is trivial to argue that neither *browse* nor *insert* will cause the label of any subject or the label of the repository to change. As a result the NRU and NWD rules must be satisfied in any state that results from either of these actions occurring from a reachable state.

25.7 **a.** For all s ∈ *subjects;*
allow (s, repository, browse(s)) iff label (s) ≤ class (repository)
allow (s, repository, insert(s)) iff label (s) ≥ class (repository)

b. The argument is similar to 25.6b. The first condition of 25.7a corresponds to no read down and the second condition of 25.7a corresponds to no write up.

25.8 **a.** Rules C1, C2, E1 **b.** Rules E2, C3 **c.** Rule E3
d. Rule C4 **e.** Rule C5 **f.** Rule E4

25.9 Drake is not authorized to read the string directly, so the no-read-up rule will prevent this. Similarly, Drake is not authorized to assign a security level of sensitive to the back-pocket file, so that is prevented as well.

25.10 Suppose the role is for top secret users. The user has the potential to read some objects at the top secret level (rts) but could then write them down to the secret level (ws), violating the *-property.
Suppose the role is for secret users. Then the rts access capability violates the simple security property.

25.11 **1.** Notify the user that a row with that primary key already exists and reject the insertion.
2. Replace the existing row at the lower level with the new row being inserted at the high level.
3. Insert the new row at the high level without modifying the existing row at the lower level (i.e., polyinstantiate the entity).

25.12 Few products are evaluated against the higher EAL 6 and EAL 7 Common Criteria assurance levels because the evaluation requirements of these levels require either semiformal or formal verification that the implementation conforms to a formal model of the security design requirements. The need to develop such a formal model and to prove implementation compliance seriously limits the type and complexity of products that can be so evaluated. Such products general only perform extremely limited functions (such as an optical keyboard/mouse/monitor switch, or a data diode to allow one-way data flow from a lower to higher classified network). Given the stringent model, design and verification requirements, it is unlikely that a general-purpose operating system, or database management system, could be evaluated to these levels.