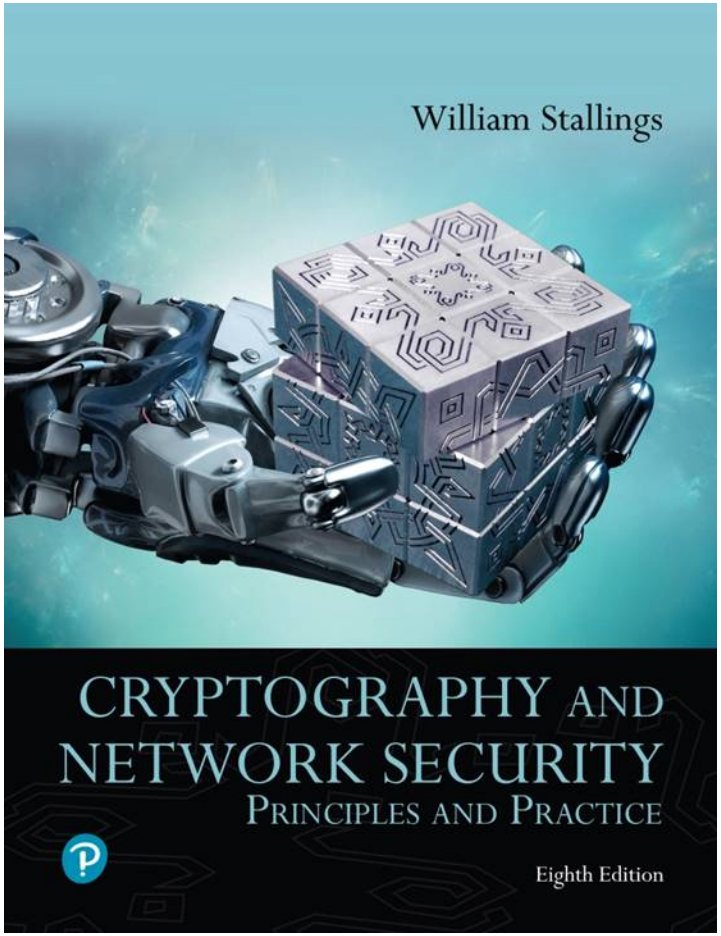
Cryptography and Network Security: Principles and Practice

Eighth Edition



Chapter 1

Information and Network Security Concepts

Pearson

Cybersecurity (1 of 3)

Cybersecurity *is the collection of tools, policies, security concepts, security safeguards, guidelines, risk management approaches, actions, training, best practices, assurance, and technologies that can be used to protect the cyberspace environment and organization and users' assets. Organization and users' assets include connected computing devices, personnel, infrastructure, applications, services, telecommunications systems, and the totality of transmitted and/or stored information in the cyberspace environment.*

Cybersecurity (2 of 3)

Cybersecurity strives to ensure the attainment and maintenance of the security properties of the organization and users' assets against relevant security risks in the cyberspace environment. The general security objectives comprise the following: availability; integrity, which may include data authenticity and nonrepudiation; and confidentiality

Kerckhoff's principle

A cryptosystem should be secure even if an attacker knows everything about the sys- tem except for the key.

Cybersecurity (3 of 3)

Information Security

- This term refers to preservation of confidentiality, integrity, and availability of information. In addition, other properties, such as authenticity, accountability, nonrepudiation, and reliability can also be involved

Network Security

- This term refers to protection of networks and their service from unauthorized modification, destruction, or disclosure, and provision of assurance that the network performs its critical functions correctly and there are no harmful side effects

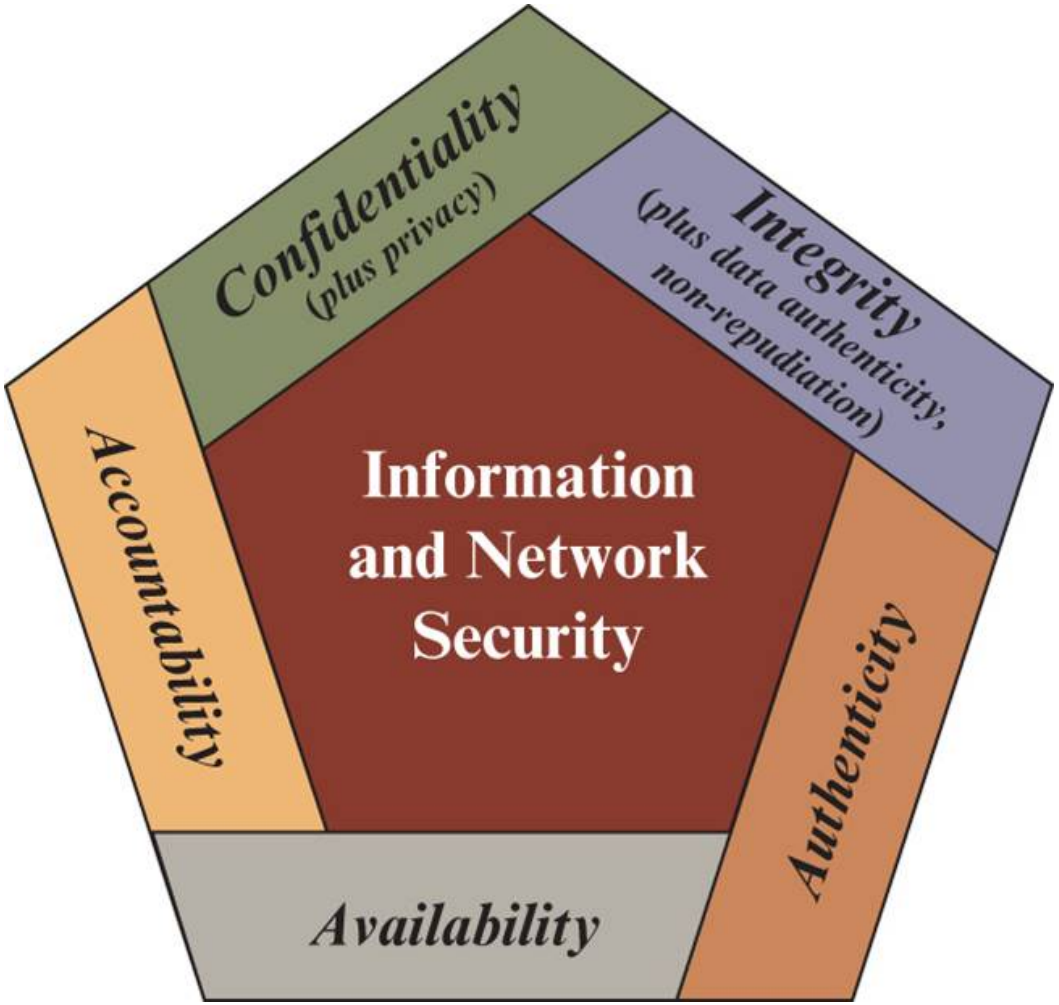
Security Objectives (1 of 2)

- The cybersecurity definition introduces three key objectives that are at the heart of information and network security:
  - **Confidentiality:** This term covers two related concepts:
    - **Data confidentiality:** Assures that private or confidential information is not made available or disclosed to unauthorized individuals
    - **Privacy:** Assures that individuals control or influence what information related to them may be collected and stored and by whom and to whom that information may be disclosed

Security Objectives (2 of 2)

- **Integrity:** This term covers two related concepts:
  - **Data integrity:** Assures that data and programs are changed only in a specified and authorized manner. This concept also encompasses data authenticity, which means that a digital object is indeed what it claims to be or what it is claimed to be, and nonrepudiation, which is assurance that the sender of information is provided with proof of delivery and the recipient is provided with proof of the sender's identity, so neither can later deny having processed the information
  - **System integrity:** Assures that a system performs its intended function in an unimpaired manner, free from deliberate or inadvertent unauthorized manipulation of the system
- **Availability:** Assures that systems work promptly and service is not denied to authorized users

Figure 1.1 Essential Information and Network Security Objectives



Computer Security Challenges

- Security is not simple
- Potential attacks on the security features need to be considered
- Procedures used to provide particular services are often counter-intuitive
- It is necessary to decide where to use the various security mechanisms
- Requires constant monitoring
- Is too often an afterthought
- Security mechanisms typically involve more than a particular algorithm or protocol
- Security is essentially a battle of wits between a perpetrator and the designer
- Little benefit from security investment is perceived until a security failure occurs
- Strong security is often viewed as an impediment to efficient and user-friendly operation

OSI Security Architecture

- Security attack
  - Any action that compromises the security of information owned by an organization
- Security mechanism
  - A process (or a device incorporating such a process) that is designed to detect, prevent, or recover from a security attack
- Security service
  - A processing or communication service that enhances the security of the data processing systems and the information transfers of an organization
  - Intended to counter security attacks, and they make use of one or more security mechanisms to provide the service

Threats and Attacks

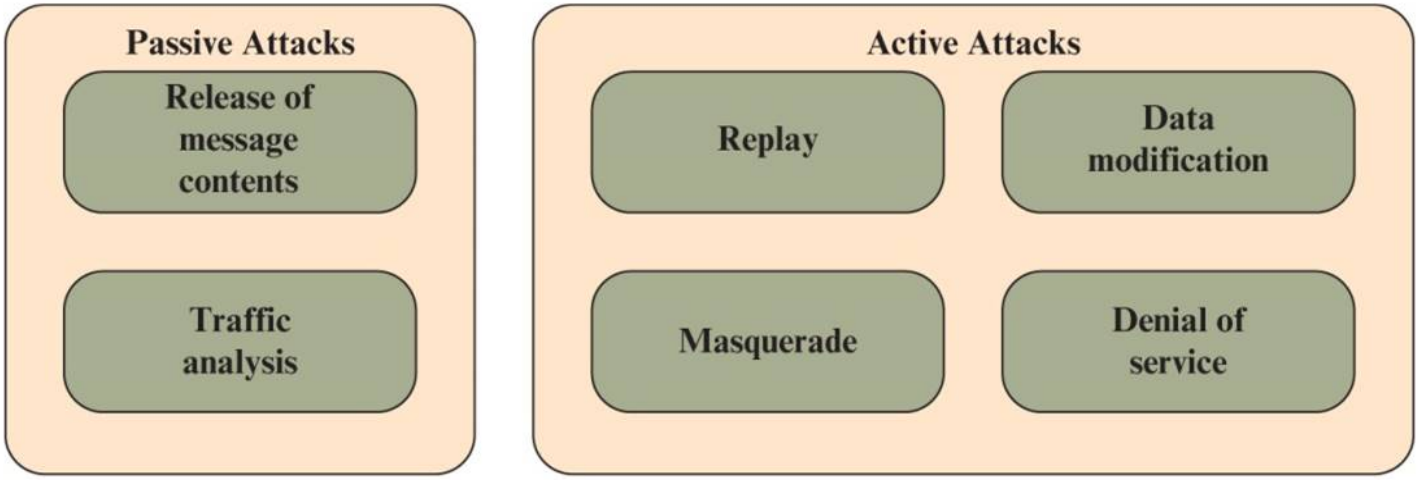
Threat

A potential for violation of security, which exists when there is a circumstance, capability, action, or event that could breach security and cause harm. That is, a threat is a possible danger that might exploit a vulnerability.

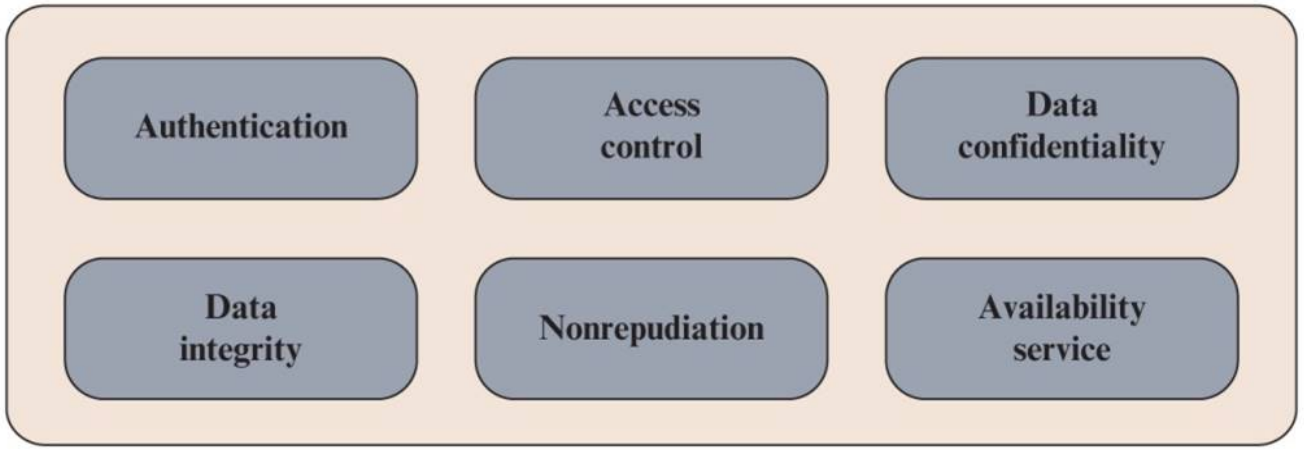
Attack

An assault on system security that derives from an intelligent threat; that is, an intelligent act that is a deliberate attempt (especially in the sense of a method or technique) to evade security services and violate the security policy of a system.

Figure 1.2 Key Concepts in Security (1 of 2)

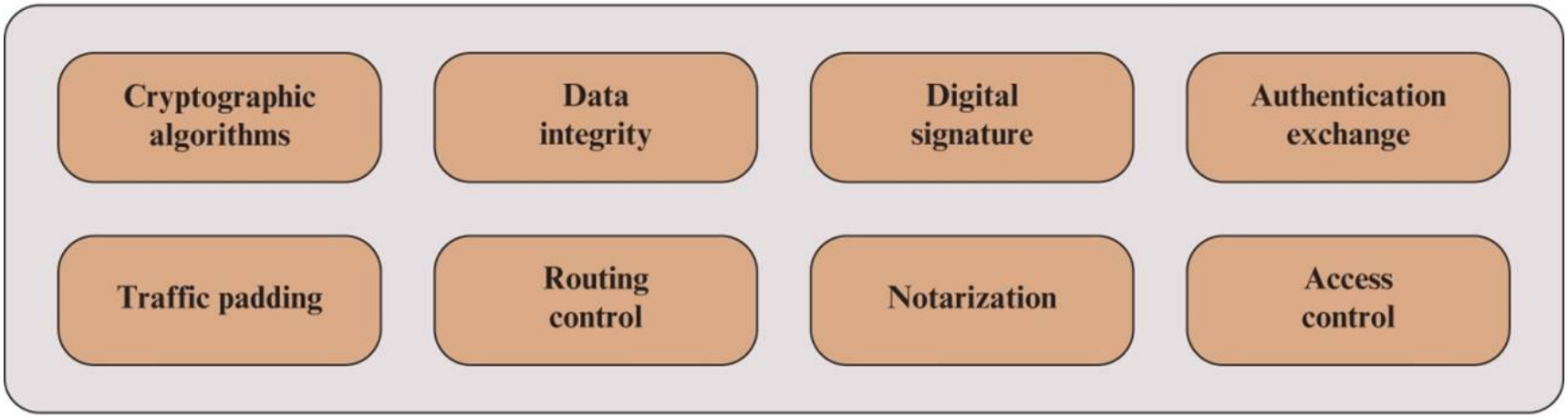


(a) Attacks



(b) Services

Figure 1.2 Key Concepts in Security
(2 of 2)



(c) Mechanisms

Security Attacks

- A means of classifying security attacks, used both in X.800 and RFC 4949, is in terms of *passive attacks* and *active attacks*
- A *passive attack* attempts to learn or make use of information from the system but does not affect system resources
- An *active attack* attempts to alter system resources or affect their operation

Passive Attacks

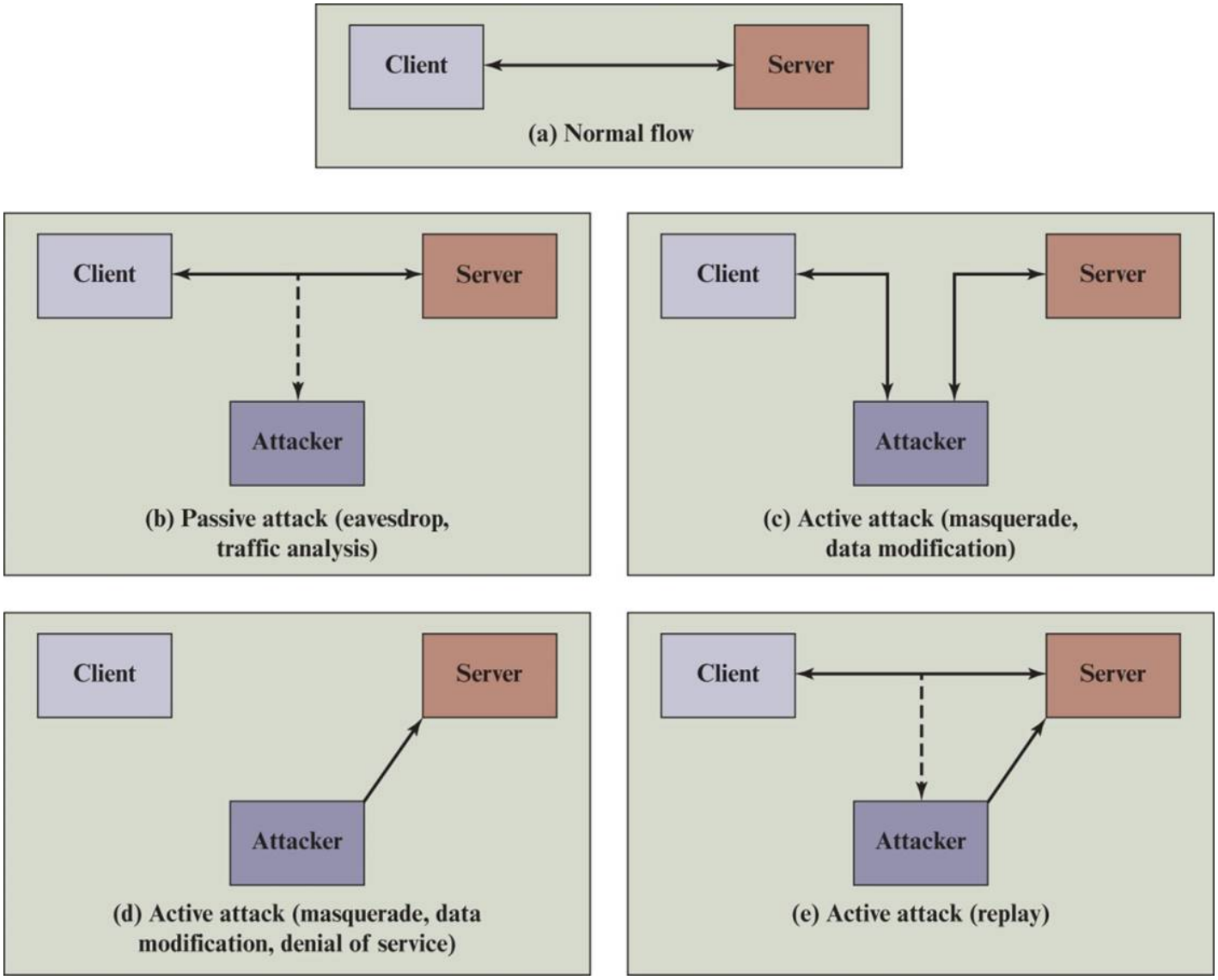
- Are in the nature of eavesdropping on, or monitoring of, transmissions
- Goal of the opponent is to obtain information that is being transmitted
- Two types of passive attacks are:
  - The release of message contents
  - Traffic analysis

Active Attacks

- Involve some modification of the data stream or the creation of a false stream
- Difficult to prevent because of the wide variety of potential physical, software, and network vulnerabilities
- Goal is to detect attacks and to recover from any disruption or delays caused by them

- Masquerade
  - Takes place when one entity pretends to be a different entity
  - Usually includes one of the other forms of active attack
- Replay
  - Involves the passive capture of a data unit and its subsequent retransmission to produce an unauthorized effect
- Data Modification
  - Some portion of a legitimate message is altered, or messages are delayed or reordered to produce an unauthorized effect
- Denial of service
  - Prevents or inhibits the normal use or management of communications facilities

Figure 1.3 Security Attacks



Authentication (1 of 2)

- Concerned with assuring that a communication is authentic
  - In the case of a single message, assures the recipient that the message is from the source that it claims to be from
  - In the case of ongoing interaction, assures the two entities are authentic and that the connection is not interfered with in such a way that a third party can masquerade as one of the two legitimate parties
- Two specific authentication services are defined in X.800:
  - Peer entity authentication
  - Data origin authentication

Authentication (2 of 2)

- **Peer entity authentication**
  - Provides for the corroboration of the identity of a peer entity in an association. Two entities are considered peers if they implement the same protocol in different systems. Peer entity authentication is provided for use at the establishment of, or at times during the data transfer phase of, a connection. It attempts to provide confidence that an entity is not performing either a masquerade or an unauthorized replay of a previous connection
- **Data origin authentication**
  - Provides for the corroboration of the source of a data unit. It does not provide protection against the duplication or modification of data units. This type of service supports applications like electronic mail, where there are no ongoing interactions between the communicating entities

Access Control

- The ability to limit and control the access to host systems and applications via communications links
- To achieve this, each entity trying to gain access must first be identified, or authenticated, so that access rights can be tailored to the individual

Data Confidentiality

- The protection of transmitted data from passive attacks
  - Broadest service protects all user data transmitted between two users over a period of time
  - Narrower forms of service includes the protection of a single message or even specific fields within a message
- The protection of traffic flow from analysis
  - This requires that an attacker not be able to observe the source and destination, frequency, length, or other characteristics of the traffic on a communications facility

Data Integrity

- Can apply to a stream of messages, a single message, or selected fields within a message
- Connection-oriented integrity service, one that deals with a stream of messages, assures that messages are received as sent with no duplication, insertion, modification, reordering, or replays
- A connectionless integrity service, one that deals with individual messages without regard to any larger context, generally provides protection against message modification only

Nonrepudiation

- Prevents either sender or receiver from denying a transmitted message
- When a message is sent, the receiver can prove that the alleged sender in fact sent the message
- When a message is received, the sender can prove that the alleged receiver in fact received the message

Availability Service

- Protects a system to ensure its availability
- This service addresses the security concerns raised by denial-of-service attacks
- It depends on proper management and control of system resources and thus depends on access control service and other security services

Security Mechanisms (1 of 2)

- **Cryptographic algorithms:** We can distinguish between reversible cryptographic mechanisms and irreversible cryptographic mechanisms. A reversible cryptographic mechanism is simply an encryption algorithm that allows data to be encrypted and subsequently decrypted. Irreversible cryptographic mechanisms include hash algorithms and message authentication codes, which are used in digital signature and message authentication applications.
- **Data integrity:** This category covers a variety of mechanisms used to assure the integrity of a data unit or stream of data units.
- **Digital signature:** Data appended to, or a cryptographic transformation of, a data unit that allows a recipient of the data unit to prove the source and integrity of the data unit and protect against forgery.

Security Mechanisms (2 of 2)

- **Authentication exchange:** A mechanism intended to ensure the identity of an entity by means of information exchange.
- **Traffic padding:** The insertion of bits into gaps in a data stream to frustrate traffic analysis attempts.
- **Routing control:** Enables selection of particular physically or logically secure routes for certain data and allows routing changes, especially when a breach of security is suspected.
- **Notarization:** The use of a trusted third party to assure certain properties of a data exchange
- **Access control:** A variety of mechanisms that enforce access rights to resources.