

Overview

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Background

Requirements of **Information Security** have changed over the last few decades:

- 🌐 Introduction of the computer for data processing
 - ☀️ Physical and administration means alone no longer sufficient
 - ☀️ Automated tools needed for protecting files stored on the *shared* computer
 - ☀️ Hence **Computer Security**
- 🌐 Introduction of distributed systems and use of networks and communication devices
 - ☀️ Data need to be protected during their transmission
 - ☀️ Hence **Network Security**
- 🌐 No clear boundaries between the two forms of security



Security Violations

Network security (on which we will spend more time) can be violated in many different ways:



- 🌐 Files with sensitive information **disclosed** during transmission
- 🌐 Remote updates to an authorization file **intercepted** and
 - ☀ **altered** or
 - ☀ **delayed**
- 🌐 **Fabricated** updates to an authorization file
- 🌐 Trading transactions subsequently **denied** by either party

Key Objectives in Security

Confidentiality

-  Data Confidentiality: sensitive information not disclosed to unauthorized entities
-  Privacy



Integrity

-  Data Integrity: data/programs changed in a specified and authorized manner
-  System Integrity: operation in the intended way

Availability

 The above is often referred to as the **CIA triad**.

Additional objectives




-  Authenticity: verifiable genuineness
-  Accountability: actions of an entity traceable

Impacts of Security Breaches

- 🌐 **Low:** limited adverse effect
 - ☀ effectiveness of primary organizational functions noticeably reduced
 - ☀ minor damage to organizational assets or financial loss
 - ☀ minor harm to individuals
- 🌐 **Moderate:** significant adverse effect
 - ☀ effectiveness of primary organizational functions significantly reduced
 - ☀ significant damage to organizational assets or financial loss
 - ☀ significant harm to individuals (but no loss of life or life-threatening injuries)
- 🌐 **High:** severe or catastrophic adverse effect
 - ☀ one or more of primary organizational functions disabled
 - ☀ major damage to organizational assets or financial loss
 - ☀ severe harm to individuals (involving loss of life or life-threatening injuries)

Why Is Network Security Complex?

- 🌐 Subtle mechanisms needed for seemingly straightforward requirements:
 - ☀️ many potential countermeasures (i.e., possible weaknesses in the mechanism) to consider
 - ☀️ some measures elaborate and counterintuitive
- 🌐 Deployment of security mechanisms
 - ☀️ physical: which points in a network
 - ☀️ logical: which layers in the protocol
- 🌐 Creation and distribution of secret information (needed by the implementation of a mechanism)
- 🌐 Unpredictable behavior of underlying communications protocols
- 🌐 All weaknesses must be found and eliminated
- 🌐 Etc.

-  **Security attack:**
any action compromising the security of information owned by an organization or individual
-  **Security mechanism:**
a mechanism designed to detect, prevent or recover from security attacks
-  **Security service:**
a service built upon one or more security mechanisms that enhances the security of information

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.



Source: Table 1.1, Stallings 2014

Security Attacks

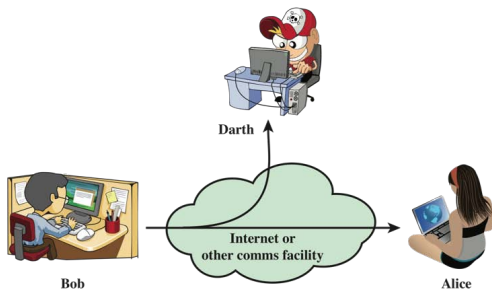
Passive attacks:

-  attempts to learn information from the system
-  does not affect system resources

Active attacks:

-  attempts to alter system resources or
-  affect their operation






Passive Attacks








Source: Figure 1.1, Stallings 2014

- 🌐 **Eavesdropping** on or monitoring of transmissions.
 - ☀️ release of message contents
 - ☀️ traffic analysis
- 🌐 Difficult to detect, but may be prevented (from success).

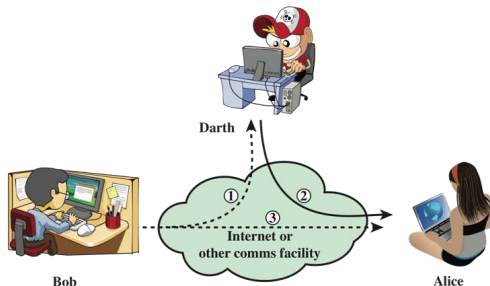
Types of information that can be derived from a traffic analysis attack:

-  Identities of partners
-  How frequently the partners are communicating
-  Message pattern, message length, or quantity of messages
-  Events correlated with conversations between particular partners
-  Messages of a *covert channel*

Active Attacks

-  **Masquerade**: one entity pretending to be another
-  **Replay**: retransmission of a captured data unit
-  **Modification of Message**: some portion of a message is altered, delayed, or reordered
-  **Denial of Service**: preventing the normal use or management of communications facilities
-  Difficult to prevent absolutely, but may be detected and recovered.

Active Attacks (cont.)



Source: Figure 1.1, Stallings 2014

- 🌐 Masquerade: 2
- 🌐 Replay: 1 + 2 + 3
- 🌐 Modification of Message: 1 + 2
- 🌐 Denial of Service: 3

Security Services (or Requirements)

- 🌐 **Authentication**: assuring that a communication is authentic
 - ☀️ Data origin authentication
 - ☀️ Peer entity authentication
- 🌐 **Access Control**: ability to limit and control access controlled
- 🌐 **Data Confidentiality** (Secrecy): protection of transmitted data or even traffic flow (from passive attacks)
- 🌐 **Data Integrity**: protection of transmitted data (from active attacks); with or without recovery
- 🌐 **Nonrepudiation**: transmission undeniable by either party
- 🌐 **Availability Service**: accessible and usable upon demand by authorized entities

Problems with Electronic Documents

Performing the functions associated with **paper documents** on **electronic documents** is challenging, due to the following aspects of electronic documents:

- 🌐 No difference between the **original** and its **copies**
- 🌐 Altering bits leaves **no physical trace**
- 🌐 Any proof of authenticity must be based on **internal evidence**

<p style="text-align: center;">AUTHENTICATION</p> <p>The assurance that the communicating entity is the one that it claims to be.</p> <p>Peer Entity Authentication Used in association with a logical connection to provide confidence in the identity of the entities connected.</p> <p>Data-Origin Authentication In a connectionless transfer, provides assurance that the source of received data is as claimed.</p> <p style="text-align: center;">ACCESS CONTROL</p> <p>The prevention of unauthorized use of a resource (i.e., this service controls who can have access to a resource, under what conditions access can occur, and what those accessing the resource are allowed to do).</p> <p style="text-align: center;">DATA CONFIDENTIALITY</p> <p>The protection of data from unauthorized disclosure.</p> <p>Connection Confidentiality The protection of all user data on a connection.</p> <p>Connectionless Confidentiality The protection of all user data in a single data block</p> <p>Selective-Field Confidentiality The confidentiality of selected fields within the user data on a connection or in a single data block.</p> <p>Traffic-Flow Confidentiality The protection of the information that might be derived from observation of traffic flows.</p>	<p style="text-align: center;">DATA INTEGRITY</p> <p>The assurance that data received are exactly as sent by an authorized entity (i.e., contain no modification, insertion, deletion, or replay).</p> <p>Connection Integrity with Recovery Provides for the integrity of all user data on a connection and detects any modification, insertion, deletion, or replay of any data within an entire data sequence, with recovery attempted.</p> <p>Connection Integrity without Recovery As above, but provides only detection without recovery.</p> <p>Selective-Field Connection Integrity Provides for the integrity of selected fields within the user data of a data block transferred over a connection and takes the form of determination of whether the selected fields have been modified, inserted, deleted, or replayed.</p> <p>Connectionless Integrity Provides for the integrity of a single connectionless data block and may take the form of detection of data modification. Additionally, a limited form of replay detection may be provided.</p> <p>Selective-Field Connectionless Integrity Provides for the integrity of selected fields within a single connectionless data block; takes the form of determination of whether the selected fields have been modified.</p> <p style="text-align: center;">NONREPUDIATION</p> <p>Provides protection against denial by one of the entities involved in a communication of having participated in all or part of the communication.</p> <p>Nonrepudiation, Origin Proof that the message was sent by the specified party.</p> <p>Nonrepudiation, Destination Proof that the message was received by the specified party.</p>
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Source: Table 1.2, Stallings 2014

- 🌐 To provide a particular security service, one utilizes a security mechanism or combine several of them
- 🌐 **Encipherment** represents one prominent class of security mechanisms.
 - ☀️ **reversible encipherment**: encryption algorithm
 - ☀️ **irreversible encipherment**: hash function, message authentication code

SPECIFIC SECURITY MECHANISMS	PERVASIVE SECURITY MECHANISMS
<p>May be incorporated into the appropriate protocol layer in order to provide some of the OSI security services.</p>	<p>Mechanisms that are not specific to any particular OSI security service or protocol layer.</p>
<p>Encipherment The use of mathematical algorithms to transform data into a form that is not readily intelligible. The transformation and subsequent recovery of the data depend on an algorithm and zero or more encryption keys.</p>	<p>Trusted Functionality That which is perceived to be correct with respect to some criteria (e.g., as established by a security policy).</p>
<p>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 (e.g., by the recipient).</p>	<p>Security Label The marking bound to a resource (which may be a data unit) that names or designates the security attributes of that resource.</p>
<p>Access Control A variety of mechanisms that enforce access rights to resources.</p>	<p>Event Detection Detection of security-relevant events.</p>
<p>Data Integrity A variety of mechanisms used to assure the integrity of a data unit or stream of data units.</p>	<p>Security Audit Trail Data collected and potentially used to facilitate a security audit, which is an independent review and examination of system records and activities.</p>
<p>Authentication Exchange A mechanism intended to ensure the identity of an entity by means of information exchange.</p>	<p>Security Recovery Deals with requests from mechanisms, such as event handling and management functions, and takes recovery actions.</p>
<p>Traffic Padding The insertion of bits into gaps in a data stream to frustrate traffic analysis attempts.</p>	
<p>Routing Control Enables selection of particular physically secure routes for certain data and allows routing changes, especially when a breach of security is suspected.</p>	
<p>Notarization The use of a trusted third party to assure certain properties of a data exchange.</p>	

Security Services vs. Mechanisms

Service	Mechanism							
	Enciph- erment	Digital signature	Access control	Data integrity	Authenti- cation exchange	Traffic padding	Routing control	Notari- zation
Peer entity authentication	Y	Y			Y			
Data origin authentication	Y	Y						
Access control			Y					
Confidentiality	Y						Y	
Traffic flow confidentiality	Y					Y	Y	
Data integrity	Y	Y		Y				
Nonrepudiation		Y		Y				Y
Availability				Y	Y			

Source: Table 1.4, Stallings 2010

Network Security Model

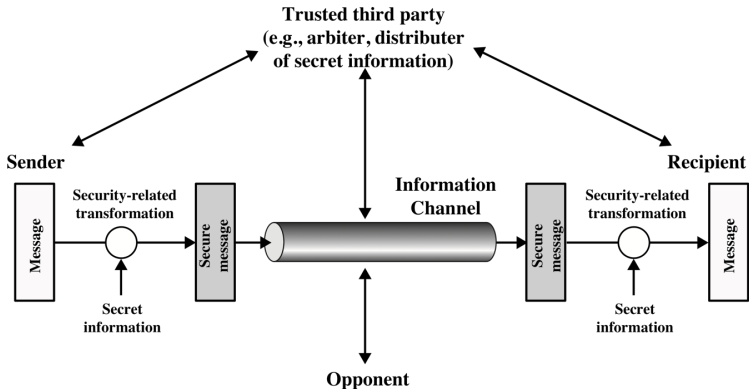


Figure 1.2 Model for Network Security

Source: Figure 1.2, Stallings 2014

Designing a Security Service

- 🌐 Design an **algorithm** for performing the security-related transformation
- 🌐 Generate the **secret information** to be used with the algorithm
- 🌐 Develop methods for **distributing** and **sharing** the secret information
- 🌐 Specify a **protocol** to be used by the two principals that make use of the security algorithm and the secret information to achieve a particular security service

Network Access Security Model

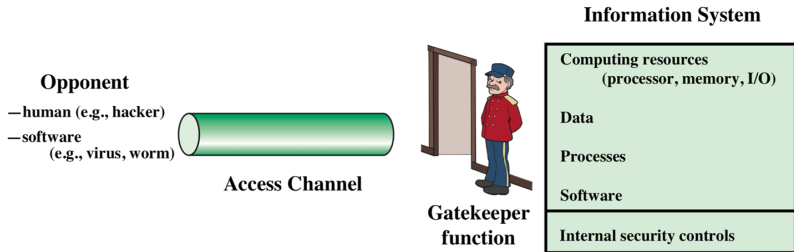


Figure 1.3 Network Access Security Model

Source: Figure 1.3, Stallings 2014