REVA UNIVERSITY

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Lecture 1.4

Computer Security Concepts

School of Computing and Information Technology

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Introduction Class

Recap of previous Lecture

TOPICS TO BE DISCUSSED (UNIT-2)

Computer Security Concepts: The OSI Security Architecture, Security Attacks, Security Services, Security Mechanisms

A Model for Network Security Symmetric Ciphers

Classical Encryption Techniques : Substitution Techniques, Transposition Techniques

Steganography

THE OSI SECURITY ARCHITECTURE

- ✓ To assess effectively the security needs of an organization and to evaluate and choose various security products and policies the manager responsible for security.

- ✓ Manager Needs some systematic way of defining the requirements for security and characterizing the approaches to satisfying those requirements.

- ✓ This is difficult enough in a centralized data processing environment, with the use of local and wide area networks, the problems are compounded

THE OSI SECURITY ARCHITECTURE

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.

THE OSI SECURITY ARCHITECTURE

- ✓ ITU-T3(The International Telecommunication Union- Telecommunication Standardization Sector) Recommendation X.800, Security Architecture for OSI, defines such a systematic approach.
- ✓ The OSI security architecture is useful for organizing the task of providing security. Furthermore, because this architecture was developed as an international standard, computer and communications vendors have developed security features for their products and services that relate to this structured definition of services and mechanisms.
- ✓ The OSI(open systems interconnection) security architecture is used by IT managers and vendors in there products.

THE OSI SECURITY ARCHITECTURE

The OSI security architecture focuses on

1. Security attacks
2. Security mechanisms
3. Security services.

- **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. The services are intended to counter security attacks, and they make use of one or more security mechanisms to provide the service.

SECURITY ATTACKS

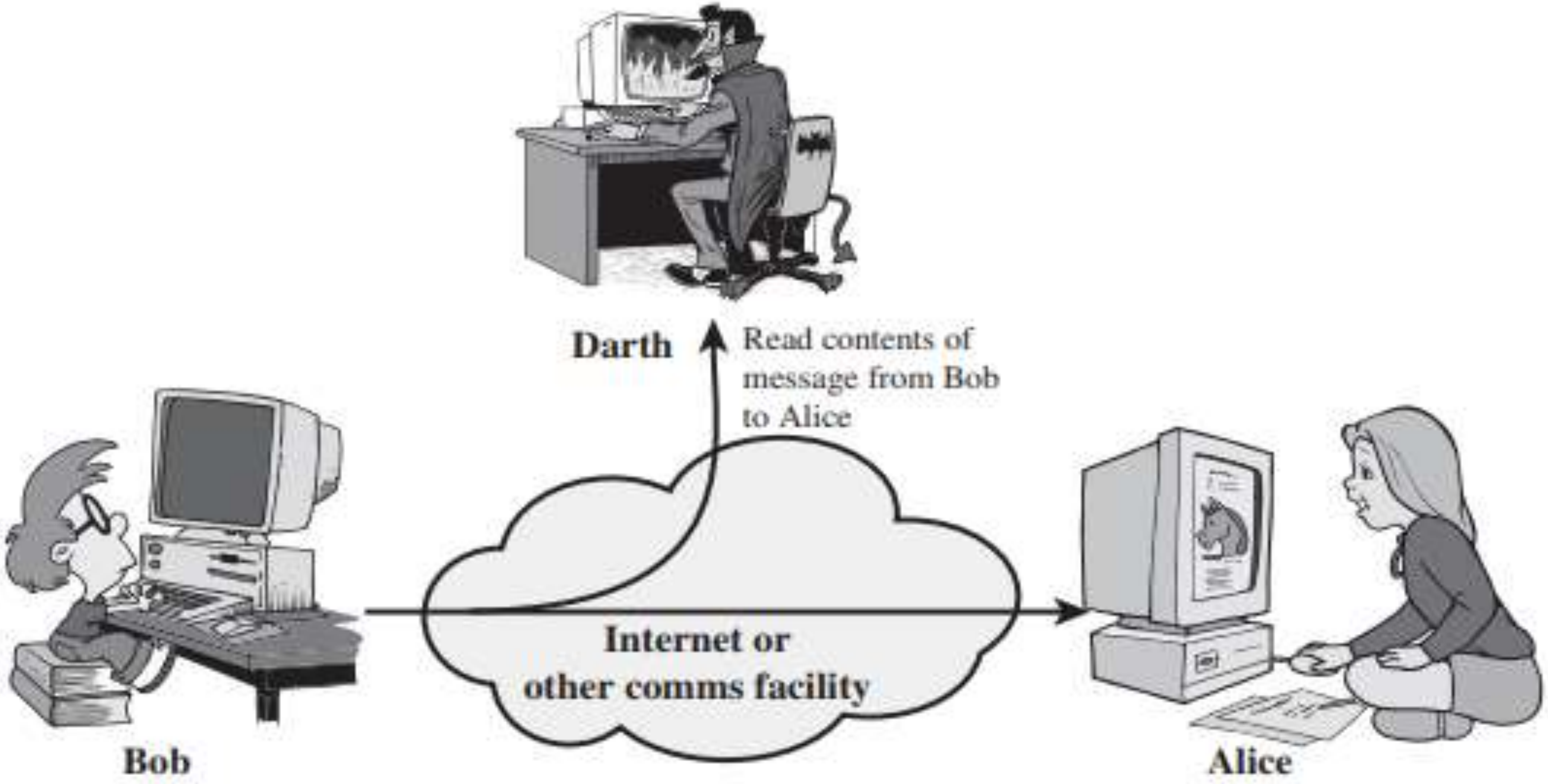
There are two types of security attacks

1. Passive Attacks
2. Active Attacks

- Passive Attacks: Passive attacks are in the nature of eavesdropping on, or monitoring of, transmissions. The goal of the opponent is to obtain information that is being transmitted.

- Two types of passive attacks are the release of message contents and traffic analysis.
- The release of message contents is easily understood (Figure 1.2a).A telephone conversation, an electronic mail message, and a transferred file may contain sensitive or confidential information. We would like to prevent an opponent from learning the contents of these transmissions.

RELEASE OF MESSAGE CONTENTS DIAGRAM



(a) Release of message contents

TRAFFIC ANALYSIS

- ✓ A second type of passive attack, traffic analysis, is subtler (Figure 1.2b). Suppose that we had a way of masking the contents of messages or other information traffic so that opponents, even if they captured the message, could not extract the information from the message. The common technique for masking contents is encryption.

- ✓ If we had encryption protection in place, an opponent might still be able to observe the pattern of these messages.

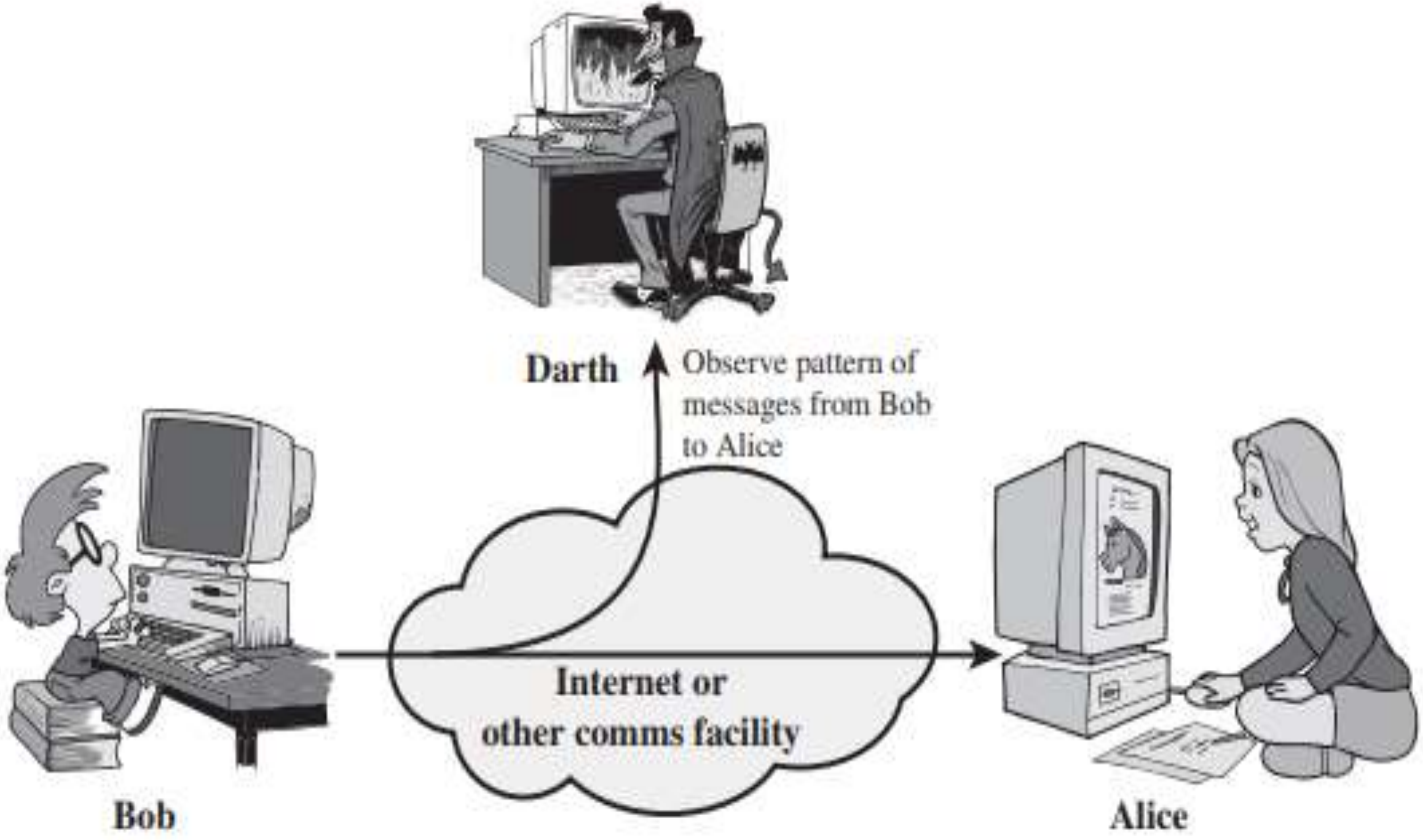
- ✓ The opponent could determine the location and identity of communicating hosts and could observe the frequency and length of messages being exchanged.

- ✓ This information might be useful in guessing the nature of the communication that was taking place.

TRAFFIC ANALYSIS

- ✓ Passive attacks are very difficult to detect, because they do not involve any alteration of the data.
- ✓ Typically, the message traffic is sent and received in an apparently normal fashion, and neither the sender nor receiver is aware that a third party has read the messages or observed the traffic pattern.
- ✓ However, it is feasible to prevent the success of these attacks, usually by means of encryption. Thus, the emphasis in dealing with passive attacks is on prevention rather than detection

TRAFFIC ANALYSIS DIAGRAM



(b) Traffic analysis

ACTIVE ATTACKS

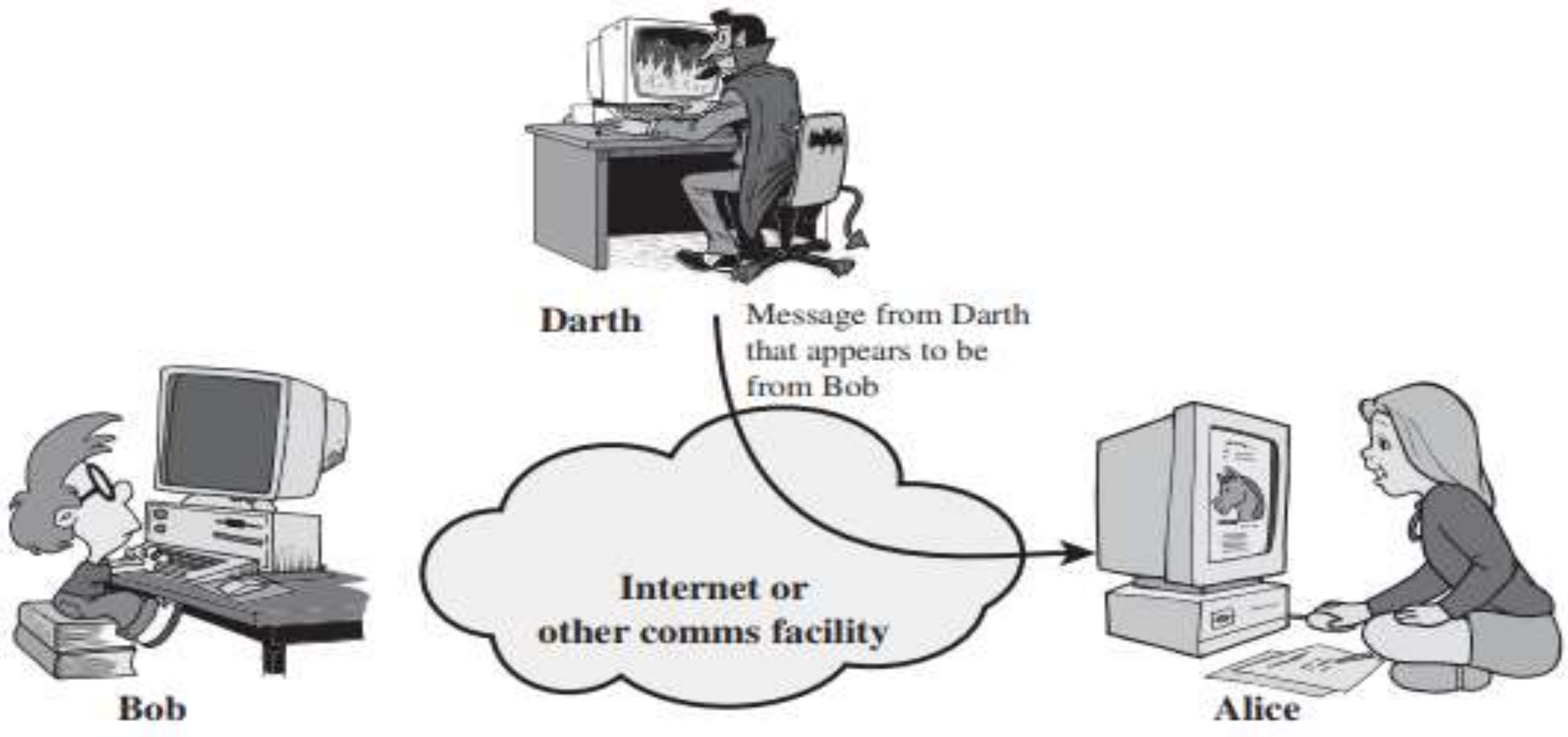
Definition:

Active attacks involve some modification of the data stream or the creation of a false stream and can be subdivided into four categories:

1. Masquerade
2. Replay
3. Modification of messages
4. Denial of service.

ACTIVE ATTACKS

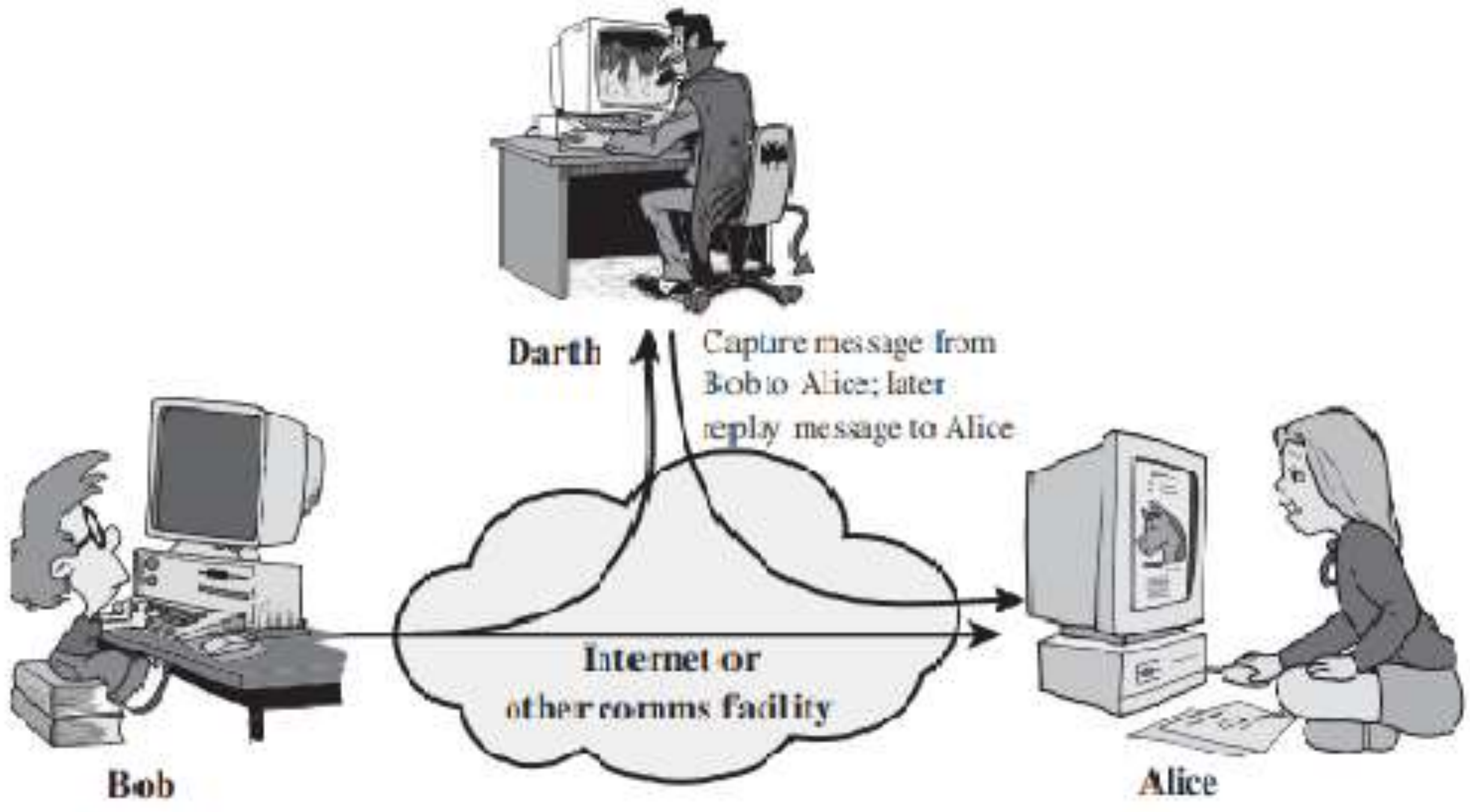
A masquerade takes place when one entity pretends to be a different entity (Figure 1.3a).A masquerade attack usually includes one of the other forms of active attack. For example, authentication sequences can be captured and replayed after a valid authentication sequence has taken place, thus enabling an authorized entity with few privileges to obtain extra privileges by impersonating an entity that has those privileges.



(a) Masquerade

ACTIVE ATTACKS

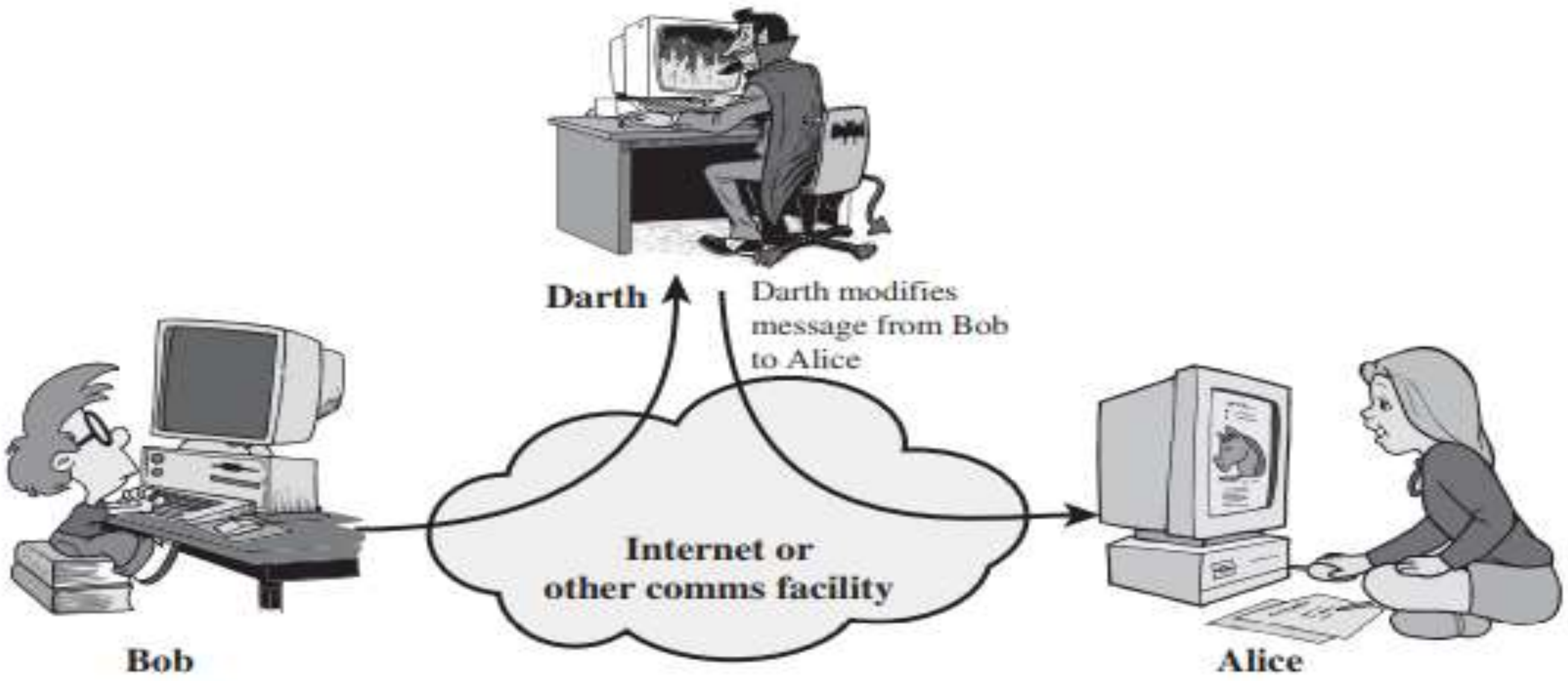
Replay involves the passive capture of a data unit and its subsequent retransmission to produce an unauthorized effect (Figure 1.3b).



(b) Replay

ACTIVE ATTACKS

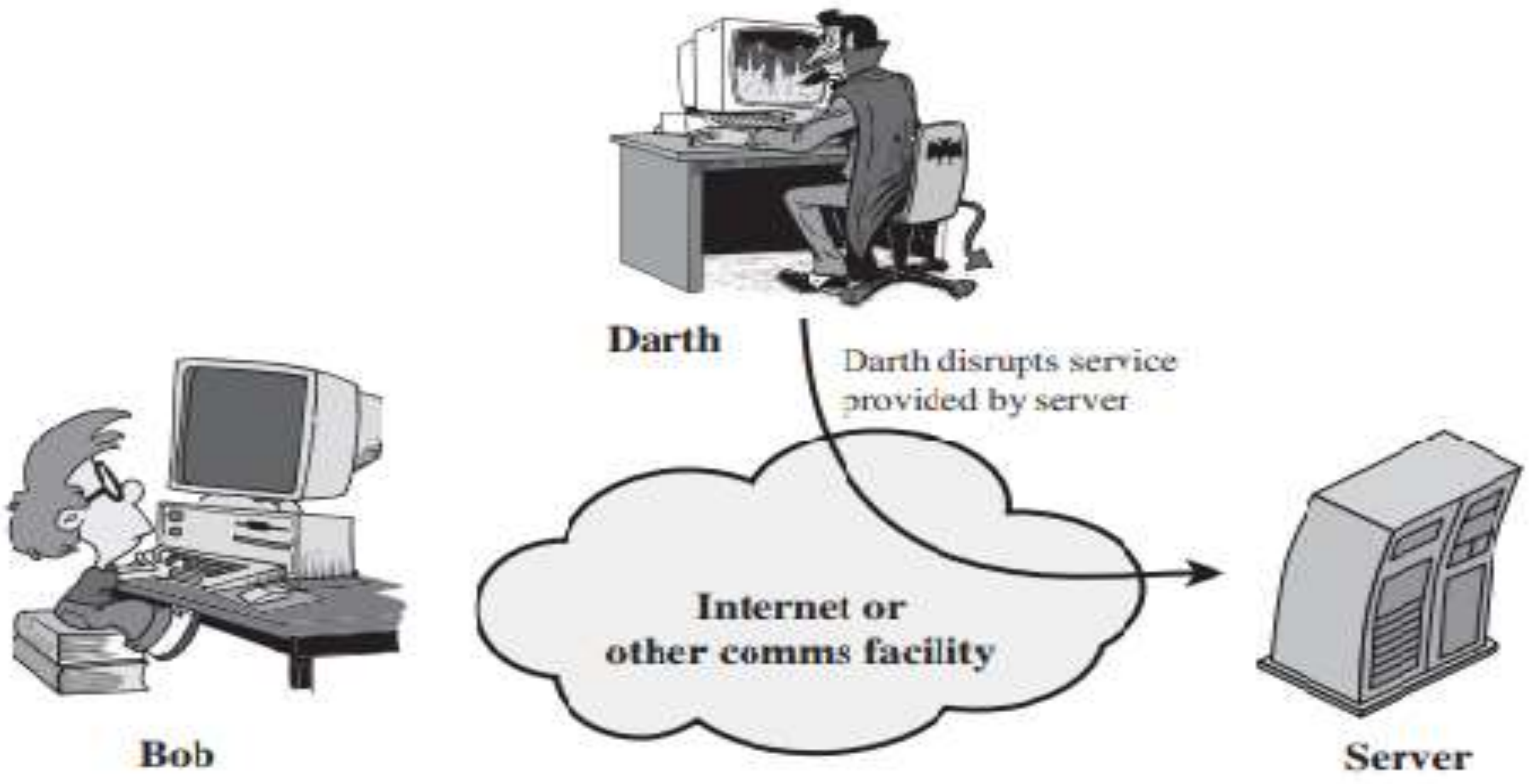
Modification of messages simply means that some portion of a legitimate message is altered, or that messages are delayed or reordered, to produce an unauthorized effect (Figure 1.3c). For example, a message meaning “Allow John Smith to read confidential file accounts” is modified to mean “Allow Fred Brown to read confidential file accounts.



(c) Modification of messages

ACTIVE ATTACKS

The denial of service prevents or inhibits the normal use or management of communications facilities (Figure 1.3d). This attack may have a specific target, for example, an entity may suppress all messages directed to a particular destination (e.g., the security audit service).Another form of service denial is the disruption of an entire network, either by disabling the network or by overloading it with messages so as to degrade performance.



(d) Denial of service

SECURITY SERVICES

- X.800 defines a security service as a service that is provided by a protocol layer of communicating open systems and that ensures adequate security of the systems or of data transfers.

- Perhaps a clearer definition is found in RFC 2828, which provides the following definition: a processing or communication service that is provided by a system to give a specific kind of protection to system resources, security services implement security policies and are implemented by security mechanisms.
- X.800 divides these services into five categories and fourteen specific services (Table 1.2). We look at each category in turn.

SECURITY SERVICES

Table 1.2 Security Services (X.800)

AUTHENTICATION	DATA INTEGRITY
The assurance that the communicating entity is the one that it claims to be. **Peer Entity Authentication** Used in association with a logical connection to provide confidence in the identity of the entities connected. **Data-Origin Authentication** In a connectionless transfer, provides assurance that the source of received data is as claimed. **ACCESS CONTROL** 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).	The assurance that data received are exactly as sent by an authorized entity (i.e., contain no modification, insertion, deletion, or replay). **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. **Connection Integrity without Recovery** As above, but provides only detection without recovery. **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.

SECURITY SERVICES

Table 1.2 Security Services (X.800)

DATA CONFIDENTIALITY The protection of data from unauthorized disclosure. **Connection Confidentiality** The protection of all user data on a connection. **Connectionless Confidentiality** The protection of all user data in a single data block **Selective-Field Confidentiality** The confidentiality of selected fields within the user data on a connection or in a single data block. **Traffic-Flow Confidentiality** The protection of the information that might be derived from observation of traffic flows.	**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. **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. **NONREPUDIATION** Provides protection against denial by one of the entities involved in a communication of having participated in all or part of the communication. **Nonrepudiation, Origin** Proof that the message was sent by the specified party. **Nonrepudiation, Destination** Proof that the message was received by the specified party.

SECURITY SERVICES

Authentication:

- ✓ The authentication service is concerned with assuring that a communication is authentic. In the case of a single message, such as a warning or alarm signal, the function of the authentication service is to assure the recipient that the message is from the source that it claims to be from.

- ✓ In the case of an ongoing interaction, such as the connection of a terminal to a host, two aspects are involved.
- ✓ First, at the time of connection initiation, the service assures that the two entities are authentic, that is, that each is the entity that it claims to be.

- ✓ Second, the service must assure that the connection is not interfered with in such a way that a third party can masquerade as one of the two legitimate parties for the purposes of unauthorized transmission or reception

SECURITY SERVICES

Two specific authentication services are defined in X.800:

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 to same protocol in different systems

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 prior interactions between the communicating entities

SECURITY SERVICES

Access Control:

In the context of network security, access control is 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:

Confidentiality is the protection of transmitted data from passive attacks. With respect to the content of a data transmission, several levels of protection can be identified. The broadest service protects all user data transmitted between two users over a period of time

Data Integrity:

As with confidentiality, integrity can apply to a stream of messages, a single message, or selected fields within a message. Again, the most useful and straightforward approach is total stream protection

A 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.

SECURITY SERVICES

Nonrepudiation:

Nonrepudiation prevents either sender or receiver from denying a transmitted message. Thus, when a message is sent, the receiver can prove that the alleged sender in fact sent the message. Similarly, when a message is received, the sender can prove that the alleged receiver in fact received the message.

Availability Service :

X.800 treats availability as a property to be associated with various security services. However, it makes sense to call out specifically an availability service. An availability service is one that 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

- ✓ Table 1.3 lists the security mechanisms defined in X.800. The mechanisms are divided into those that are implemented in a specific protocol layer, such as TCP or an application-layer protocol, and those that are not specific to any particular protocol layer or security service.

- ✓ X.800 distinguishes between reversible encipherment mechanisms and irreversible encipherment mechanisms.

- ✓ A reversible encipherment mechanism is simply an encryption algorithm that allows data to be encrypted and subsequently decrypted.

- ✓ Irreversible encipherment mechanisms include hash algorithms and message authentication codes, which are used in digital signature and message authentication applications

SECURITY MECHANISMS

Table 1.3 Security Mechanisms (X.800)

SPECIFIC SECURITY MECHANISMS	PERVASIVE SECURITY MECHANISMS
May be incorporated into the appropriate protocol layer in order to provide some of the OSI security services.	Mechanisms that are not specific to any particular OSI security service or protocol layer.
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.	**Trusted Functionality** That which is perceived to be correct with respect to some criteria (e.g., as established by a security policy).
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).	**Security Label** The marking bound to a resource (which may be a data unit) that names or designates the security attributes of that resource.
Access Control A variety of mechanisms that enforce access rights to resources.	**Event Detection** Detection of security-relevant events. **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.

SECURITY MECHANISMS

Data Integrity A variety of mechanisms used to assure the integrity of a data unit or stream of data units. **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 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.	**Security Recovery** Deals with requests from mechanisms, such as event handling and management functions, and takes recovery actions.

SECURITY MECHANISMS

Table 1.4, based on one in X.800, indicates the relationship between security services and security mechanisms.

Table 1.4 Relationship Between Security Services and Mechanisms

	Mechanism							
Service	**Encipherment**	**Digital Signature**	**Access Control**	**Data Integrity**	**Authentication Exchange**	**Traffic Padding**	**Routing Control**	**Notarization**
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			

A MODEL FOR NETWORK SECURITY SYMMETRIC CIPHERS

- A symmetric encryption scheme has five ingredients (Figure 2.1):

- Plaintext: This is the original intelligible message or data that is fed into the algorithm as input.
- Encryption algorithm: The encryption algorithm performs various substitutions and transformations on the plaintext.
- Secret key: The secret key is also input to the encryption algorithm. The key is a value independent of the plaintext and of the algorithm. The algorithm will produce a different output depending on the specific key being used at the time. The exact substitutions and transformations performed by the algorithm depend on the key.
- Ciphertext: This is the scrambled message produced as output. It depends on the plaintext and the secret key. For a given message, two different keys will produce two different ciphertexts. The ciphertext is an apparently random stream of data and, as it stands, is unintelligible.

A MODEL FOR NETWORK SECURITY SYMMETRIC CIPHERS

- Decryption algorithm: This is essentially the encryption algorithm run in reverse. It takes the ciphertext and the secret key and produces the original plaintext.

There are two requirements for secure use of conventional encryption:

1. We need a strong encryption algorithm. At a minimum, we would like the algorithm to be such that an opponent who knows the algorithm and has access to one or more ciphertexts would be unable to decipher the ciphertext or figure out the key. This requirement is usually stated in a stronger form. The opponent should be unable to decrypt ciphertext or discover the key even if he or she is in possession of a number of ciphertexts together with the plaintext that produced each ciphertext.

2. Sender and receiver must have obtained copies of the secret key in a secure fashion and must keep the key secure. If someone can discover the key and knows the algorithm, all communication using this key is readable

A MODEL FOR NETWORK SECURITY SYMMETRIC CIPHERS

- What is Ciphertext

Ciphertext is encrypted text transformed from plaintext using an encryption algorithm. Ciphertext can't be read until it has been converted into plaintext (decrypted) with a key. The decryption cipher is an algorithm that transforms the ciphertext back into plaintext.

What is the use of a cipher in cryptography?

Ciphertext Cipher is an algorithm which is applied to plain text to get ciphertext. It is the unreadable output of an encryption algorithm. The term "cipher" is sometimes used as an alternative term for ciphertext. Ciphertext is not understandable until it has been converted into plain text using a key.

Advanced Encryption Standard

AES is an iterative rather than Feistel cipher. It is based on 'substitution–permutation network'. It comprises of a series of linked operations, some of which involve replacing inputs by specific outputs (substitutions) and others involve shuffling bits around (permutations). Interestingly, AES performs all its computations on bytes rather than bits. Hence, AES treats the 128 bits of a plaintext block as 16 bytes. These 16 bytes are arranged in four columns and four rows for processing as a matrix

A MODEL FOR NETWORK SECURITY SYMMETRIC CIPHERS

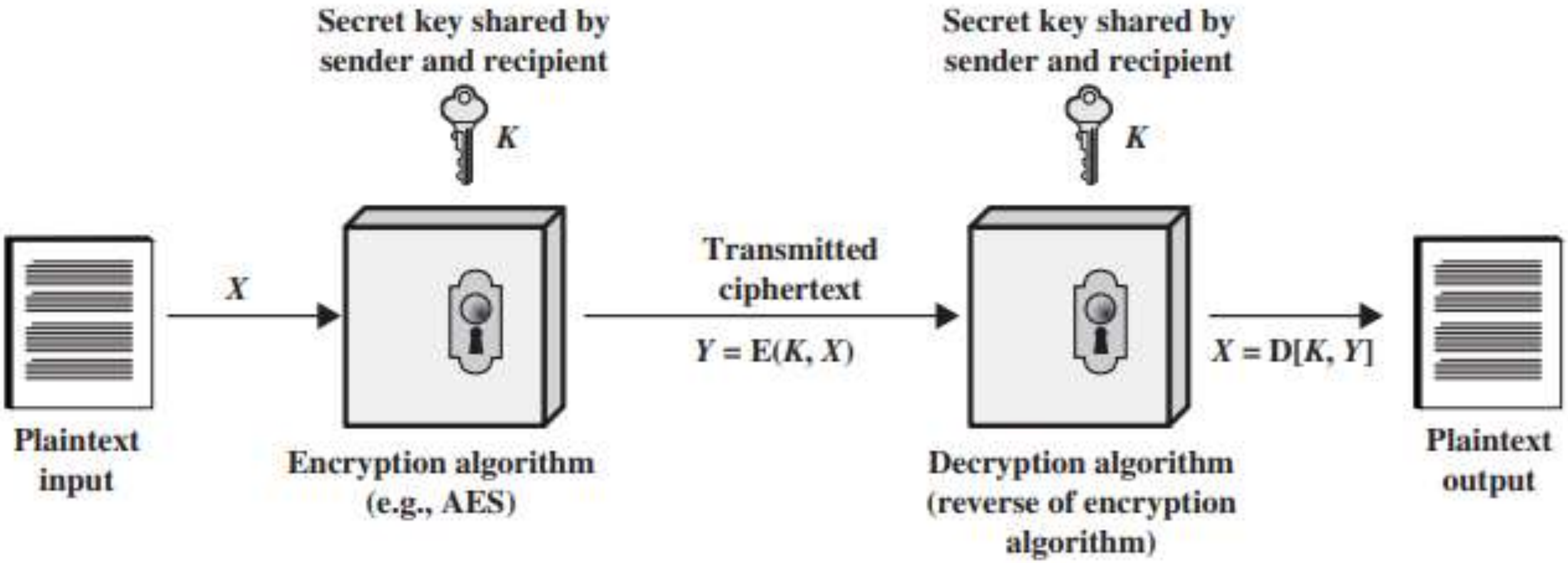


Figure 2.1 Simplified Model of Symmetric Encryption

A MODEL FOR NETWORK SECURITY SYMMETRIC CIPHERS

Model of Symmetric Cryptosystem

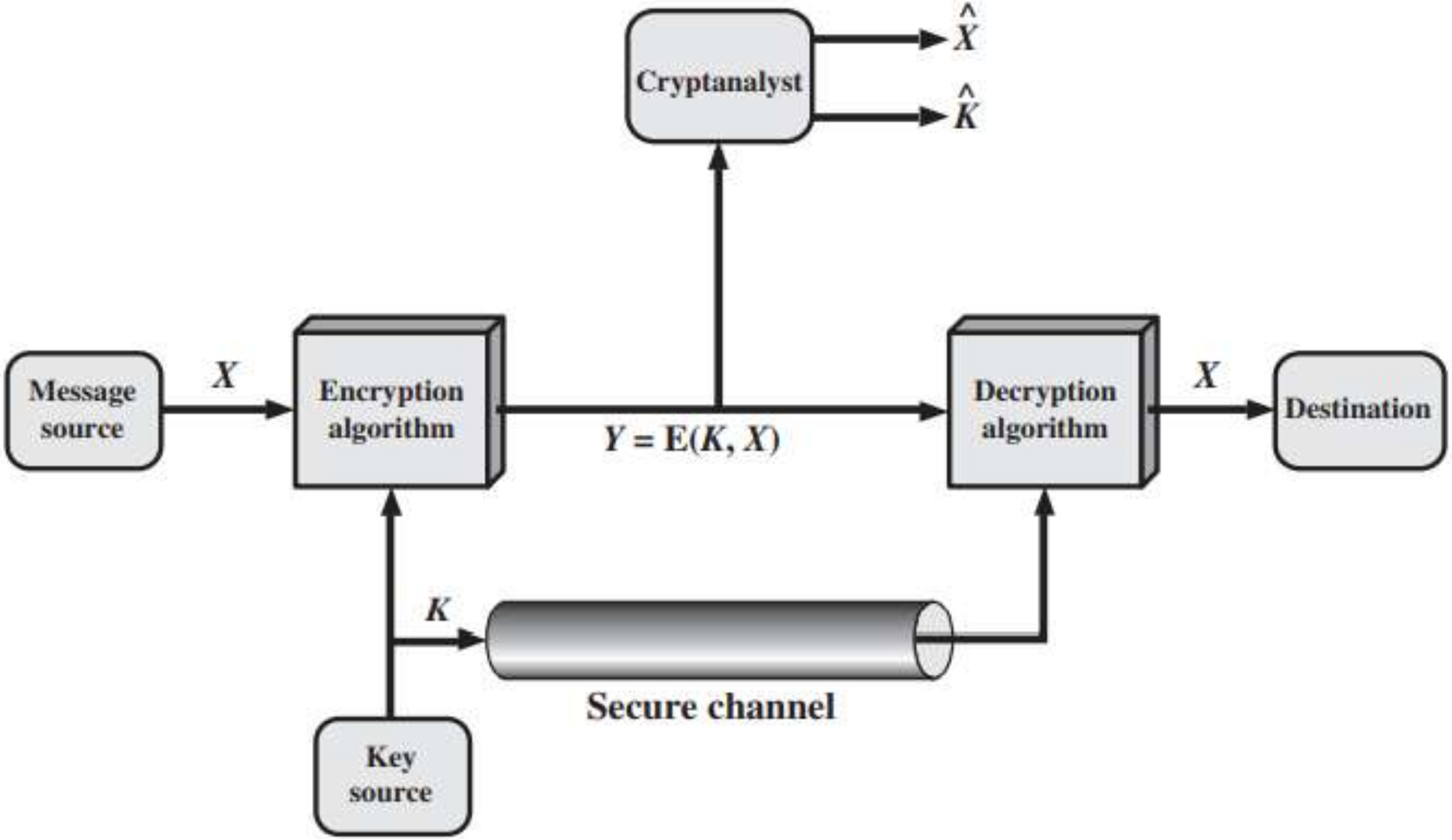


Figure 2.2 Model of Symmetric Cryptosystem

STEGANOGRAPHY.

- A plaintext message may be hidden in one of two ways. The methods of steganography conceal(hide) the existence of the message, whereas the methods of cryptography render the message unintelligible to outsiders by various transformations of the text.

- A simple form of steganography, but one that is time-consuming to construct, is one in which an arrangement of words or letters within an apparently innocuous text spells out the real message.

Various other techniques have been used historically; some examples are the following:

Character marking: Selected letters of printed or typewritten text are overwritten in pencil. The marks are ordinarily not visible unless the paper is held at an angle to bright light.

STEGANOGRAPHY.

- Invisible ink: A number of substances can be used for writing but leave no visible trace until heat or some chemical is applied to the paper.
- Pin punctures: Small pin punctures on selected letters are ordinarily not visible unless the paper is held up in front of a light.
- Typewriter correction ribbon: Used between lines typed with a black ribbon, the results of typing with the correction tape are visible only under a strong light.

(CLASSICAL ENCRYPTION TECHNIQUES)SUBSTITUTION TECHNIQUES.

A substitution technique is one in which the letters of plaintext are replaced by other letters or by numbers or symbols. If the plaintext is viewed as a sequence of bits, then substitution involves replacing plaintext bit patterns with ciphertext bit patterns.

There are six types of Substitution techniques, listed below:

- Caesar Cipher
- Monoalphabetic Ciphers
- Playfair Cipher
- Hill Cipher
- Polyalphabetic Ciphers
- One-Time Pad

CLASSICAL ENCRYPTION TECHNIQUES.

Caesar Cipher :

use of a substitution cipher was by Julius Caesar. The Caesar cipher involves replacing each letter of the alphabet with the letter standing three places further down the alphabet. For example

```
plain:  meet me after the toga party
cipher: PHHW PH DIWHU WKH WRJD SDUWB
```

Note that the alphabet is wrapped around, so that the letter following Z is A. We can define the transformation by listing all possibilities, as follows:

```
plain:  a b c d e f g h i j k l m n o p q r s t u v w x y z
cipher: D E F G H I J K L M N O P Q R S T U V W X Y Z A B C
```

Let us assign a numerical equivalent to each letter:

a	b	c	d	e	f	g	h	i	j	k	l	m
0	1	2	3	4	5	6	7	8	9	10	11	12

n	o	p	q	r	s	t	u	v	w	x	y	z
13	14	15	16	17	18	19	20	21	22	23	24	25

CLASSICAL ENCRYPTION TECHNIQUES.

Caesar Cipher :

Then the algorithm can be expressed as follows. For each plaintext letter p, substitute the ciphertext letter C:[2]

$$C = \mathrm{E}(3, p) = (p + 3) \bmod 26$$

A shift may be of any amount, so that the general Caesar algorithm is

$$C = \mathrm{E}(k, p) = (p + k) \bmod 26 \qquad \textbf{(2.1)}$$

where k takes on a value in the range 1 to 25. The decryption algorithm is simply

$$p = \mathrm{D}(k, C) = (C - k) \bmod 26 \qquad \textbf{(2.2)}$$

CLASSICAL ENCRYPTION TECHNIQUES.

Three important characteristics of this problem enabled us to use a bruteforce cryptanalysis:

1. The encryption and decryption algorithms are known.
2. There are only 25 keys to try.
3. The language of the plaintext is known and easily recognizable

KEY	PHHW PH DIWHU WKH WRJD SDUWB
1	oggv og chvgt vjg vqic rctva
2	nffu nf bgufs uif uphb qbsuz
3	meet me after the toga party
4	ldds ld zesdq sgd snfz ozqsx
5	kccr kc ydrcp rfc rmey nyprw
6	jbbq jb xcqbo qeb qldx mxoqv
7	iaap ia wbpan pda pkcw lwnpu
8	hzzo hz vaozm ocz ojbv kvmot
9	gyyn gy uznyl nby niau julns
10	fxxm fx tymxk max mhzt itkmr
11	ewwl ew sxlwj lzw lgys hsjlq
12	dvvk dv rwkvi kyv kfxr grikp
13	cuuj cu qvjuh jxu jewq fqhjo
14	btti bt puitg iwt idvp epgin
15	assh as othsf hvs hcuo dofhm
16	zrrg zr nsgre gur gbtn cnegl
17	yqqf yq mrfqd ftq fasm bmdfk
18	xppe xp lqepc esp ezrl alcej
19	wood wo kpdob dro dyqk zkbdi
20	vnnc vn jocna cqn cxpj yjach
21	ummb um inbmz bpm bwoi xizbg
22	tlla tl hmaly aol avnh whyaf
23	skkz sk glzkx znk zumg vgxze
24	rjjy rj fkyjw ymj ytlf ufwyd
25	qiix qi ejxiv xli xske tevxc

Figure 2.3 Brute-Force Cryptanalysis of Caesar Cipher

MONOALPHABETIC CIPHERS

With only 25 possible keys, the Caesar cipher is far from secure. A dramatic increase in the key space can be achieved by allowing an arbitrary substitution. Before proceeding, we define the term permutation. A permutation of a finite set of elements is an ordered sequence of all the elements of , with each element appearing exactly once. For example, if , there are six permutations of :

abc, acb, bac, bca, cab, cba

In general, there are ! permutations of a set of elements, If, instead, the “cipher” line can be any permutation of the 26 alphabetic characters, then there are 26! or greater than possible keys $4 * 10^{26}$

plain:	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z
cipher:	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C

Cipher Text

UZQSOVUOHXMOPVGPOZPEVSGZWSZOPFPESXUDBMETSXAIZ
VUEPHZHMDZSHZOWSFPAPPDTSVPQUZWYMXUZUHSX
EPYEPOPDZSZUFPOMBZWPFUPZHMDJUDTMOHMQ

P 13.33	H 5.83	F 3.33	B 1.67	C 0.00
Z 11.67	D 5.00	W 3.33	G 1.67	K 0.00
S 8.33	E 5.00	Q 2.50	Y 1.67	L 0.00
U 8.33	V 4.17	T 2.50	I 0.83	N 0.00
O 7.50	X 4.17	A 1.67	J 0.83	R 0.00
M 6.67				

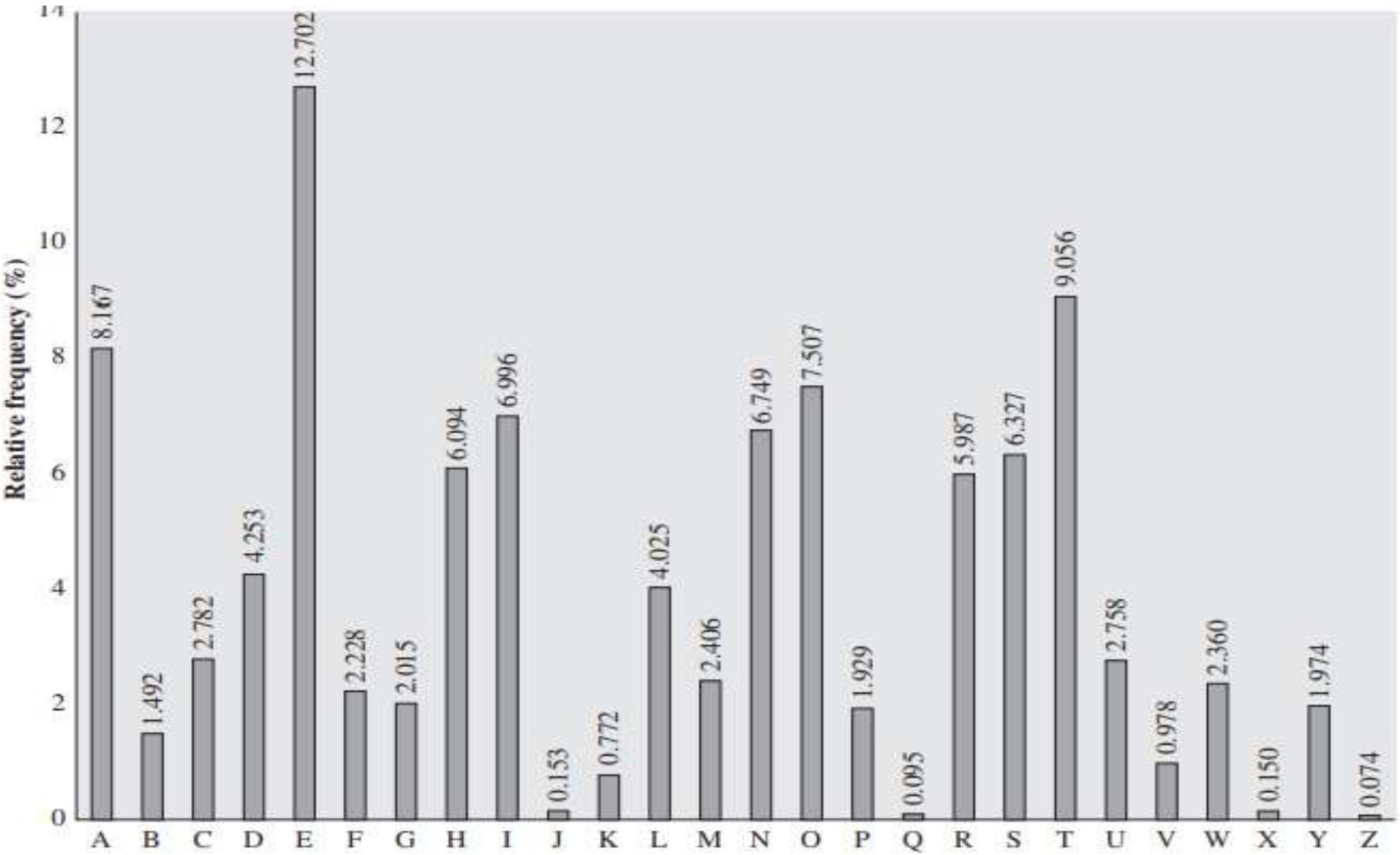


Figure 2.5 Relative Frequency of Letters in English Text

```
UZQSOVUOHXMOPVGPOZPEVSGZWSZOPFPESXUDBMETSXAIZ
 t a        e  e te  a that e e a       a
VUEPHZHMDZSHZOWSFPAPPDTSVPQUZWYMXUZUHSX
   e t   ta t ha e ee  a e  th    t  a
EPYEPOPDZSZUFPOMBZWPFUPZHMDJUDTMOHMQ
 e  e e tat  e   the   t
```

Original Message

```
it was disclosed yesterday that several informal but
direct contacts have been made with political
representatives of the viet cong in moscow
```

PLAYFAIR CIPHER

- The Playfair Cipher was first described by Charles Wheatstone in 1854. It is named after(Lord Peter Wimsey) Lord Playfair, who heavily promoted the use of the cipher to the military.

- It is a polyalphabetic substitution cipher, meaning that one letter can be denoted by different letters in its encryption, depending on the keyword used, which is given to both parties.

- A 5x5 matrix is drawn, and letters are filled in each cell, starting with the keyword, followed by the letters in the alphabet. I/J are filled in the same cell. All repeating letters are removed, giving us a matrix.

C	H	A	R	L
E	S			

C	H	A	R	L
E	S	B	D	F
G	I/J	K	M	N
O	P	Q	T	U
V	W	X	Y	Z

RULE-1

Given a plaintext sentence, it is split into digrams, removing all spaces, and padding with the letter x in case of an odd number of letters. Repeating plaintext letters are separated with a filler letter such as x.

Given the sentence

Meet me at the bridge

me et me at th eb ri dg ex

RULE-2

Two plaintext letters in the same row of the matrix are each replaced by the letter to the right, with the first element of the row circularly following the last.

C	H	A	R	L
E	S	B	D	F
G	I/J	K	M	N
O	P	Q	T	U
V	W	X	Y	Z

eb would be replaced by sd

ng would be replaced by gi/gj

RULE-3

Two plaintext letters that fall in the same column of the matrix are replaced by the letters beneath, with the top element of the column circularly following the bottom.

C	H	A	R	L
E	S	B	D	F
G	I/J	K	M	N
O	P	Q	T	U
V	W	X	Y	Z

dt would be replaced by my

ty would be replaced by yr

RULE-4

Otherwise, each plaintext letter in a pair is replaced by the letter that lies in its own row and the column occupied by the other plaintext letter.

C	H	A	R	L
E	S	B	D	F
G	I/J	K	M	N
O	P	Q	T	U
V	W	X	Y	Z

me would be replaced by gd

et would be replaced by do

ONE-TIME PAD

- An Army Signal Corp officer, Joseph Mauborgne, proposed an improvement to the Vernam cipher that yields the ultimate in security.
- Mauborgne suggested using a random key that is as long as the message, so that the key need not be repeated. In addition, the key is to be used to encrypt and decrypt a single message, and then is discarded.
- Each new message requires a new key of the same length as the new message.
- Such a scheme, known as a one-time pad, is unbreakable. It produces random output that bears no statistical relationship to the plaintext.
- Because the ciphertext contains no information whatsoever about the plaintext, there is simply no way to break the code

ONE-TIME PAD

- An example should illustrate our point. Suppose that we are using a Vigenère scheme with 27 characters in which the twenty-seventh character is the space character, but with a one-time key that is as long as the message. Consider the ciphertext

ANKYODKYUREPFJBYOJDSPLREYIUNOFDOIUERFPLUYTS

We now show two different decryptions using two different keys:

ciphertext: ANKYODKYUREPFJBYOJDSPLREYIUNOFDOIUERFPLUYTS

key: pxlmvmsydofuyrvzwc tnlebnecvgdupahfzzlmnyih

plaintext: mr mustard with the candlestick in the hal

ciphertext: ANKYODKYUREPFJBYOJDSPLREYIUNOFDOIUERFPLUYTS

key: mfugpmiydgaxgoufhklllmhsqdqogtewbqfgyovuhwt

plaintext: miss scarlet with the knife in the library

ONE-TIME PAD

- In theory, we need look no further for a cipher. The one-time pad offers complete security but, in practice, has two fundamental difficulties:

1. There is the practical problem of making large quantities of random keys. Any heavily used system might require millions of random characters on a regular basis. Supplying truly random characters in this volume is a significant task.
2. Even more daunting is the problem of key distribution and protection. For every message to be sent, a key of equal length is needed by both sender and receiver. Thus, a mammoth key distribution problem exists.

Because of these difficulties, the one-time pad is of limited utility and is useful primarily for low-bandwidth channels requiring very high security.

The one-time pad is the only cryptosystem that exhibits what is referred to as perfect secrecy.

HILL CIPHER

- **Hill cipher** is a polygraphic substitution cipher based on linear algebra

Encryption

Each letter is represented by a number modulo 26. Though this is not an essential feature of the cipher, this simple scheme is often used

Letter	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
Number	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25

- To encrypt a message, each block of n letters (considered as an n-component vector) is multiplied by an invertible $n \times n$ matrix, against modulus 26.
- To decrypt the message, each block is multiplied by the inverse of the matrix used for encryption.
- The matrix used for encryption is the cipher key, and it should be chosen randomly from the set of invertible $n \times n$ matrices (modulo 26).
- The cipher can, of course, be adapted to an alphabet with any number of letters; all arithmetic just needs to be done modulo the number of letters instead of modulo 26.

Consider the message 'ACT', and the key below (or GYB/NQK/URP in letters):

$$\begin{pmatrix} 6 & 24 & 1 \\ 13 & 16 & 10 \\ 20 & 17 & 15 \end{pmatrix}$$

Since 'A' is 0, 'C' is 2 and 'T' is 19, the message is the vector:

$$\begin{pmatrix} 0 \\ 2 \\ 19 \end{pmatrix}$$

Thus the enciphered vector is given by:

$$\begin{pmatrix} 6 & 24 & 1 \\ 13 & 16 & 10 \\ 20 & 17 & 15 \end{pmatrix} \begin{pmatrix} 0 \\ 2 \\ 19 \end{pmatrix} = \begin{pmatrix} 67 \\ 222 \\ 319 \end{pmatrix} \equiv \begin{pmatrix} 15 \\ 14 \\ 7 \end{pmatrix} \pmod{26}$$

POLYALPHABETIC CIPHERS

- Another way to improve on the simple monoalphabetic technique is to use different monoalphabetic substitutions as one proceeds through the plaintext message.
- The general name for this approach is polyalphabetic substitution cipher. All these techniques have the following features in common:

  1. A set of related monoalphabetic substitution rules is used.
  2. A key determines which particular rule is chosen for a given transformation.

VIGENÈRE CIPHER The best known, and one of the simplest, polyalphabetic ciphers is the Vigenère cipher. In this scheme, the set of related monoalphabetic substitution rules consists of the 26 Caesar ciphers with shifts of 0 through 25. Each cipher is denoted by a key letter, which is the ciphertext letter that substitutes for the plaintext letter a. Thus, a Caesar cipher with a shift of 3 is denoted by the key value *d*.

We can express the Vigenère cipher in the following manner. Assume a sequence of plaintext letters $P = p_0, p_1, p_2, \ldots, p_{n-1}$ and a key consisting of the sequence of letters $K = k_0, k_1, k_2, \ldots, k_{m-1}$, where typically $m < n$. The sequence of ciphertext letters $C = C_0, C_1, C_2, \ldots, C_{n-1}$ is calculated as follows:

POLYALPHABETIC CIPHERS

Thus, the first letter of the key is added to the first letter of the plaintext, mod 26, the second letters are added, and so on through the first m letters of the plaintext. For the next m letters of the plaintext, the key letters are repeated. This process continues until all of the plaintext sequence is encrypted. A general equation of the encryption process is

$$C_i = (p_i + k_{i \bmod m}) \bmod 26 \tag{2.3}$$

Compare this with Equation (2.1) for the Caesar cipher. In essence, each plaintext character is encrypted with a different Caesar cipher, depending on the corresponding key character. Similarly, decryption is a generalization of Equation (2.2):

$$p_i = (C_i - k_{i \bmod m}) \bmod 26 \tag{2.4}$$

To encrypt a message, a key is needed that is as long as the message. Usually, the key is a repeating keyword. For example, if the keyword is *deceptive*, the message "we are discovered save yourself" is encrypted as

POLYALPHABETIC CIPHERS

```
key:          deceptivedeceptivedeceptive
plaintext:    wearediscoveredsaveyourself
ciphertext:   ZICVTWQNGRZGVTWAVZHCQYGLMGJ
```

Expressed numerically, we have the following result.

key	3	4	2	4	15	19	8	21	4	3	4	2	4	15
plaintext	22	4	0	17	4	3	8	18	2	14	21	4	17	4
ciphertext	25	8	2	21	19	22	16	13	6	17	25	6	21	19

key	19	8	21	4	3	4	2	4	15	19	8	21	4
plaintext	3	18	0	21	4	24	14	20	17	18	4	11	5
ciphertext	22	0	21	25	7	2	16	24	6	11	12	6	9

The strength of this cipher is that there are multiple ciphertext letters for each plaintext letter, one for each unique letter of the keyword. Thus, the letter frequency information is obscured. However, not all knowledge of the plaintext structure is lost. For example, Figure 2.6 shows the frequency distribution for a Vigenère cipher with a keyword of length 9. An improvement is achieved over the Playfair cipher, but considerable frequency information remains.

POLYALPHABETIC CIPHERS

VERNAM CIPHER The ultimate defense against such a cryptanalysis is to choose a keyword that is as long as the plaintext and has no statistical relationship to it. Such a system was introduced by an AT&T engineer named Gilbert Vernam in 1918. His system works on binary data (bits) rather than letters. The system can be expressed succinctly as follows (Figure 2.7):

$$c_i = p_i \oplus k_i$$

where

p_i = ith binary digit of plaintext
k_i = ith binary digit of key
c_i = ith binary digit of ciphertext
$\oplus$ = exclusive-or (XOR) operation

Compare this with Equation (2.3) for the Vigenère cipher.

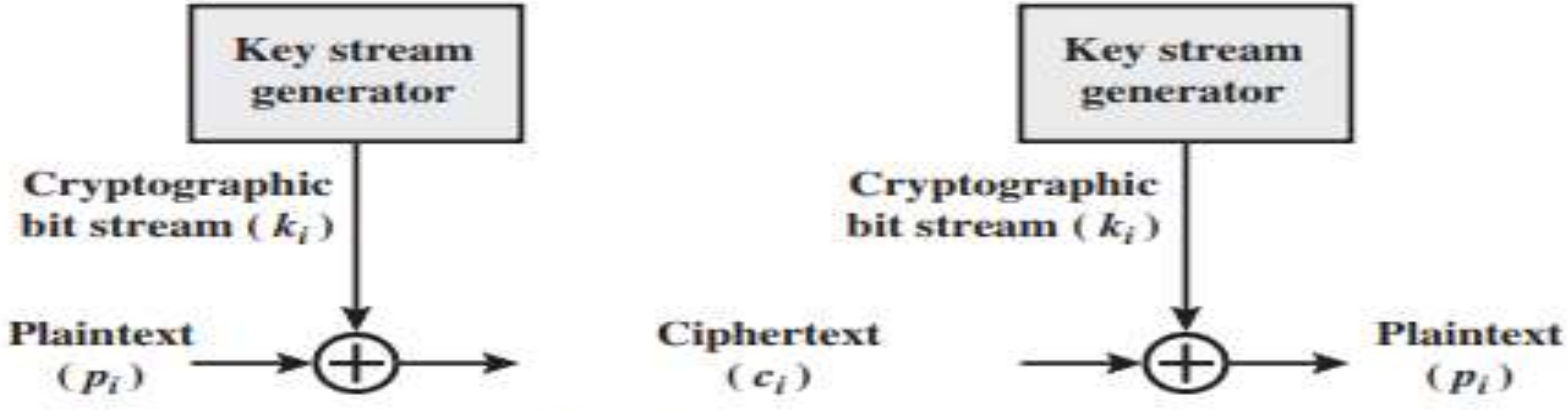


Figure 2.7 Vernam Cipher

POLYALPHABETIC CIPHERS

Thus, the ciphertext is generated by performing the bitwise XOR of the plaintext and the key. Because of the properties of the XOR, decryption simply involves the same bitwise operation:

$$p_i = c_i \oplus k_i$$

which compares with Equation (2.4).

The essence of this technique is the means of construction of the key. Vernam proposed the use of a running loop of tape that eventually repeated the key, so that in fact the system worked with a very long but repeating keyword. Although such a scheme, with a long key, presents formidable cryptanalytic difficulties, it can be broken with sufficient ciphertext, the use of known or probable plaintext sequences, or both.

TRANSPOSITION TECHNIQUES

- All the techniques examined so far involve the substitution of a ciphertext symbol for a plaintext symbol. A very different kind of mapping is achieved by performing some sort of permutation on the plaintext letters. This technique is referred to as a transposition cipher.
- The simplest such cipher is the rail fence technique.
- In which the plaintext is written down as a sequence of diagonals and then read off as a sequence of rows. For example, to encipher the message "meet me after the toga party" with a rail fence of depth 2,

we write the following:

m e m a t r h t g p r y

e t e f e t e o a a t

The encrypted message is

MEMATRHTGPRYETEFETEOAAT

TRANSPOSITION TECHNIQUES

This sort of thing would be trivial to cryptanalyze. A more complex scheme is to write the message in a rectangle, row by row, and read the message off, column by column, but permute the order of the columns.

The order of the columns then becomes the key to the algorithm.

For example,

Key: 4 3 1 2 5 6 7 Plaintext: a t t a c k p o s t p o n e d u n t i l t w o a m x y z

Ciphertext: TTNAAPTMTSUOAODWCOIXKNLYPETZ Thus,

in this example, the key is 4312567. To encrypt, start with the column that is labeled 1, in this case column 3.Write down all the letters in that column. Proceed to column 4, which is labeled 2, then column 2, then column 1, then columns 5, 6, and 7

TRANSPOSITION TECHNIQUES

A pure transposition cipher is easily recognized because it has the same letter frequencies as the original plaintext. For the type of columnar transposition just shown, cryptanalysis is fairly straightforward and involves laying out the ciphertext in a matrix and playing around with column positions. Diagram and trigram frequency tables can be useful

SUMMARY OF THE LECTURE

Computer Security Concepts: The OSI Security Architecture, Security Attacks, Security Services, Security Mechanisms

A Model for Network Security Symmetric Ciphers

Classical Encryption Techniques : Substitution Techniques, Transposition Techniques

Steganography

DISCUSSION


discussion
students
group
questions
person
class
conversation
minutes
think
one
time
way
participants
question
people
comment
Discussion
comments
groups
critical
know
tolerance
new
ideas
another
good
responses
made
feel
like
quote
detectives
different
others
Students
someone
newspaper
newsprint
also
ask
power
practice
contributions
room
storyteller
learning
make
just
talk
might
specific
possible
team
work
give
first
get
two
view
Marcuse
whole
right
thinking
speak
something
important
next
asked
want
help
point
assumptions
repressive
really
John
use
see
rule
small
things
course
much
mean
DISCUSSION
circle
Learning
words
written
White
exercise
issue
read
well
going
democratic
everyone
minute
leader
topic
Gary
voices
saying
speaking
perspective
perspectives
must
week
MINUTES
ground
response
best
around
alternative
participation
discussions
allowed
write
large
process
three
open
station
arguments
take
members
idea
end
start
life
already
interpretations
least
sheet
voice
choose
need
Make
student
move
wish
One
practices
Critical
else
adult
used
back
talking
drawn