APPLICATION LAYER

Unit: 5

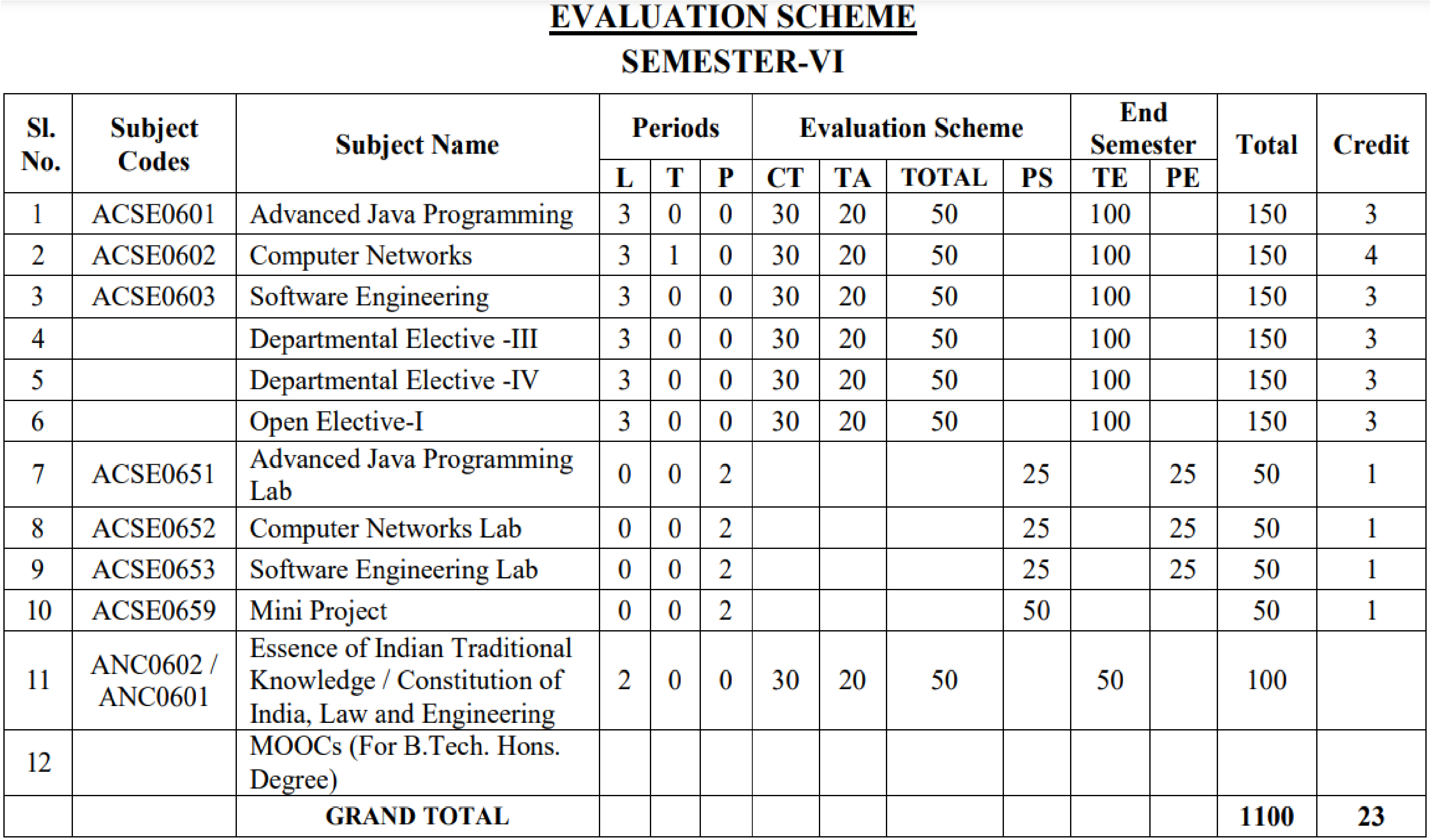
Computer Network

(ACSE0602)

B Tech (CSE) 6th Sem

Sanjay Nayak
(Assistant Professor)
CSE
Department

Evaluation Scheme



EVALUATION SCHEME

SEMESTER-VI

Sl. No.	Subject Codes	Subject Name	Periods			Evaluation Scheme				End Semester		Total	Credit
			L	T	P	CT	TA	TOTAL	PS	TE	PE		
1	ACSE0601	Advanced Java Programming	3	0	0	30	20	50		100		150	3
2	ACSE0602	Computer Networks	3	1	0	30	20	50		100		150	4
3	ACSE0603	Software Engineering	3	0	0	30	20	50		100		150	3
4		Departmental Elective -III	3	0	0	30	20	50		100		150	3
5		Departmental Elective -IV	3	0	0	30	20	50		100		150	3
6		Open Elective-I	3	0	0	30	20	50		100		150	3
7	ACSE0651	Advanced Java Programming Lab	0	0	2				25		25	50	1
8	ACSE0652	Computer Networks Lab	0	0	2				25		25	50	1
9	ACSE0653	Software Engineering Lab	0	0	2				25		25	50	1
10	ACSE0659	Mini Project	0	0	2				50			50	1
11	ANC0602 / ANC0601	Essence of Indian Traditional Knowledge / Constitution of India, Law and Engineering	2	0	0	30	20	50		50		100	
12		MOOCs (For B.Tech. Hons. Degree)											
		GRAND TOTAL										**1100**	**23**

Syllabus by University

Course Contents / Syllabus	
UNIT-I Introduction	8 Hr
Goals and applications of networks, Categories of networks, Organization of the Internet, ISP, The OSI reference model, TCP/IP protocol suite, Network devices and components, Mode of communications Physical Layer: Network topology design, Types of connections, LAN, MAN and MAN Transmission media, Signal transmission and encoding, Network performance and transmission impairments, Switching techniques and multiplexing, IEEE standards.	
UNIT-II Data Link layer	8 Hr
Framing, Error Detection and Correction, Flow control (Elementary Data Link Protocols, Sliding Window protocols). Medium Access Control and Local Area Networks: Channel allocation, Multiple access protocols, LAN standards, Link layer switches & bridges.	

Syllabus by University

Course Contents / Syllabus		
UNIT-III	Network Layer	8 Hr
Point-to-point networks, Logical addressing, Basic internetworking (IP, CIDR, ARP, RARP, DHCP, ICMP), IPv4, Routing, forwarding and delivery, Static and dynamic routing, Routing algorithms and protocols, Congestion control algorithms, IPv6.		
UNIT-IV	Transport Layer	8 Hr
Process-to-process delivery, Transport layer protocols (UDP and TCP), Connection management, Flow control and retransmission, Window management, TCP Congestion control, Quality of service.		
UNIT-V	Application Layer	8 Hr
Domain Name System, World Wide Web and Hyper Text Transfer Protocol, Electronic mail, File Transfer Protocol, Remote login, Network management, Data compression, VPN, Cryptography – basic concepts, Firewalls.		

References

- **Text Books:**

1. B. A. Forouzan, “Data Communications and Networking”, 5th Edition, TMH, 2017.

- **Reference Books:**

1. S. Tanenbaum, “Computer Networks”, 4th Edition, Pearson, 2013.

2. W. Stallings, “Data and Computer Communication”, 8th Edition, Pearson, 2007.

Branch Wise Applications

- Fiber optic cables find many uses in a wide variety of industries and applications. Some uses of fiber optic cables include:
- **Medical**
  Used as light guides, imaging tools and also as lasers for surgeries
- **Defense/Government**
  Used as hydrophones for seismic waves and SONAR , as wiring in aircraft, submarines and other vehicles and also for field networking
- **Data Storage**
  Used for data transmission
- **Telecommunications**
  Fiber is laid and used for transmitting and receiving purposes
- **Networking**
  Used to connect users and servers in a variety of network settings and help increase the speed and accuracy of data transmission
- **Industrial/Commercial**
  Used for imaging in hard to reach areas, as wiring where EMI is an issue, as sensory devices to make temperature, pressure and other measurements, and as wiring in automobiles and in industrial settings
- **Broadcast/CATV**
  Broadcast/cable companies are using fiber optic cables for wiring CATV, HDTV, internet, video on-demand and other applications

Course Objective

The objective of this course is to understand introduction of computer networks with suitable transmission media and different networking devices. Network protocols which are essential for the computer network are need to explain such as data link layer protocols and routing protocols.

A detail explanation of IP addressing , TCP/IP protocols and application layer protocols are covered in this course.

Course Outcome

Cos	**Outcomes** **After Completion of the Course Student will be able to**
CO1	Build an understanding of the fundamental concepts and Layered Architecture of computer networking.
CO2	Understand the basic concepts of link layer properties to detect error and develop the solution for error control and flow control
CO3	Design, calculate, and apply subnet masks and addresses to fulfil networking requirements and calculate distance among routers in subne
CO4	Understand the duties of transport layer, Session layer with connection management of TCP protocol
CO5	Discuss the different protocols used at application layer

Program Outcomes

1. Engineering knowledge
2. Problem analysis
3. Design/development of solutions
4. Conduct investigations of complex problems
5. Modern tool usage
6. The engineer and society
7. Environment and sustainability
8. Ethics
9. Individual and team work
10. Communication
11. Project management and finance
12. Life-long learning

CO-PO Mapping

Computer Networks (ACSE0602)									Year of Study: 2024			
CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	3	2	2		2				2		2	3
CO-2	3	3	2									3
CO-3	3	3	3	3	2				2		2	3
CO-4	3	2	2		2							3
CO-5	3	3	2		2	3		2				3
CO-6	**3**	**2**	**2**		**2**	**2**	**2**	**2**		**2**	**2**	**3**

PSO’s

Program Specific Outcomes	Course Outcome				
	CO1	CO2	CO3	CO4	C05
PSO1	2	2	2	2	2
PSO2	2	2	2	2	2
PSO3	2	2	2	3	2
AVERAGE	2	2	2	2.3	2

Program Educational Objectives

PEO 1: To have an excellent scientific and engineering breadth so as to comprehend, analyze, design and provide sustainable solutions for real-life problems using state-of-the-art technologies.

PEO 2: To have a successful career in industries, to pursue higher studies or to support entrepreneurial endeavors and to face the global challenges.

PEO 3: To have an effective communication skills, professional attitude, ethical values and a desire to learn specific knowledge in emerging trends, technologies for research, innovation and product development and contribution to society.

PEO 4: To have life-long learning for up-skilling and re-skilling for successful professional career as engineer, scientist, entrepreneur and bureaucrat for betterment of society.

Result Analysis

COMPUTER NETWORK (ACSE0602)	
Department wise Result of VI sem.	NA
Subject wise result	NA
Faculty wise result	NA

Prerequisite and Recap

- Basics of Digital communication
- Knowledge of Computer.
- Fundamental of Digital logic design

Brief Introduction About Subject with videos

- An introduction to Computer networks and covers fundamental topics like data, information to the definition of communication and computer networks.

- The main objective of data communication and networking is to enable seamless exchange of data between any two points in the world.

- This exchange of data takes place over a computer network.
- **https://www.youtube.com/watch?v=O--rkQNKqls&list=PLbRMhDVUMngf-peFloB7kyiA40EptH1up**

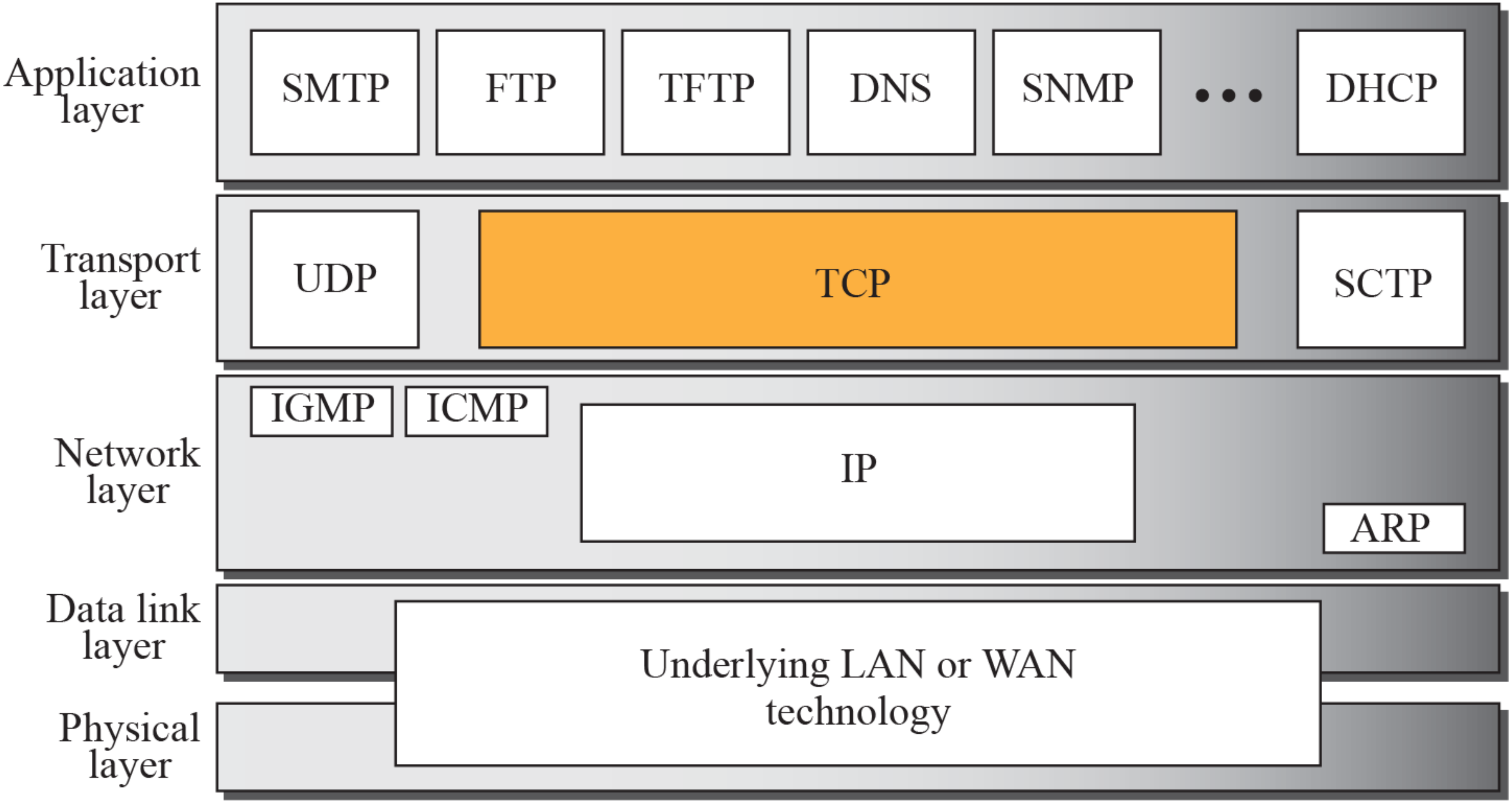
Topic Objective and its mapping with CO

Name of Topic	**Objective of Topic**	**Mapping with CO**
File Transfer Protocol	Student will be able to learn about Protocol of Application Layer. .	CO5
Electronic Mail	Student will be able to learn how various elements of Electronic mail (E-mail) .	CO5
Cryptography	Student will be able to learn about How to make system cryptography in networking .	CO5
Network Security	Student will be able to learn how to ensure security of network .	CO5

Prerequisite

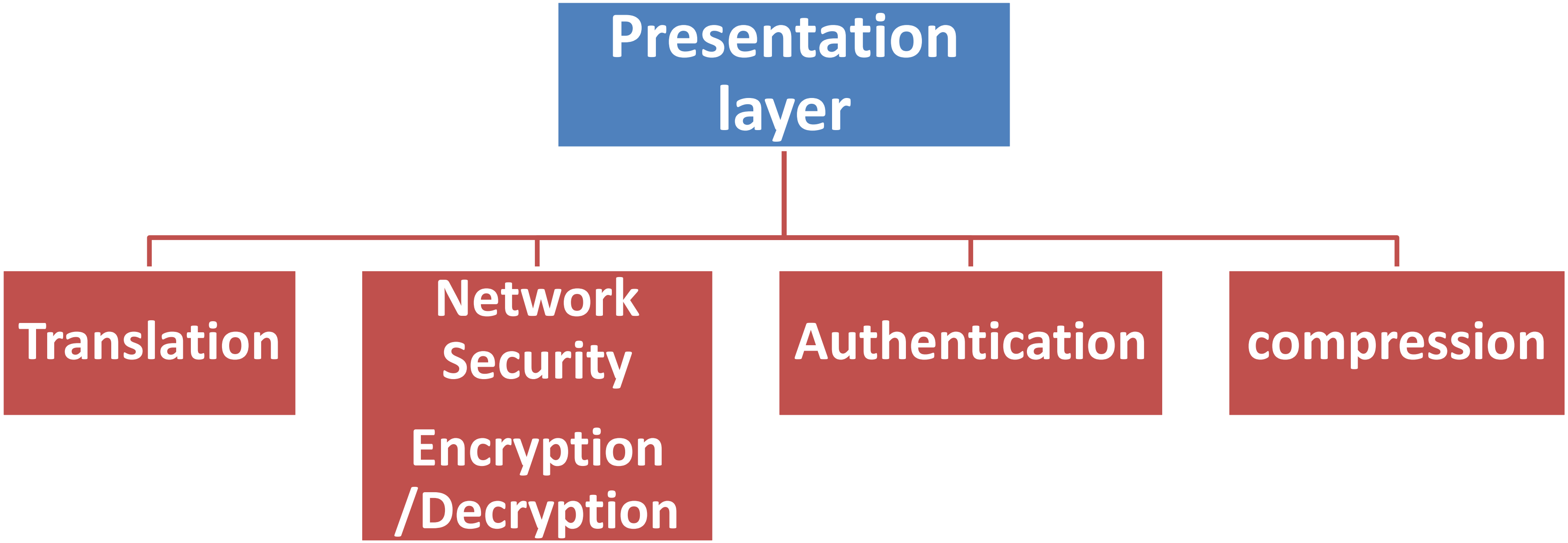
- Basic understanding of types of Protocol of Application Layer.
- Basic knowledge of physical layer.
- Basic knowledge of data link layer.
- Network Topology Design
- Point-to-Point Protocol

TCP/ IP model



SCTP stands for Stream Control Transmission **Protocol**

Presentation Layer

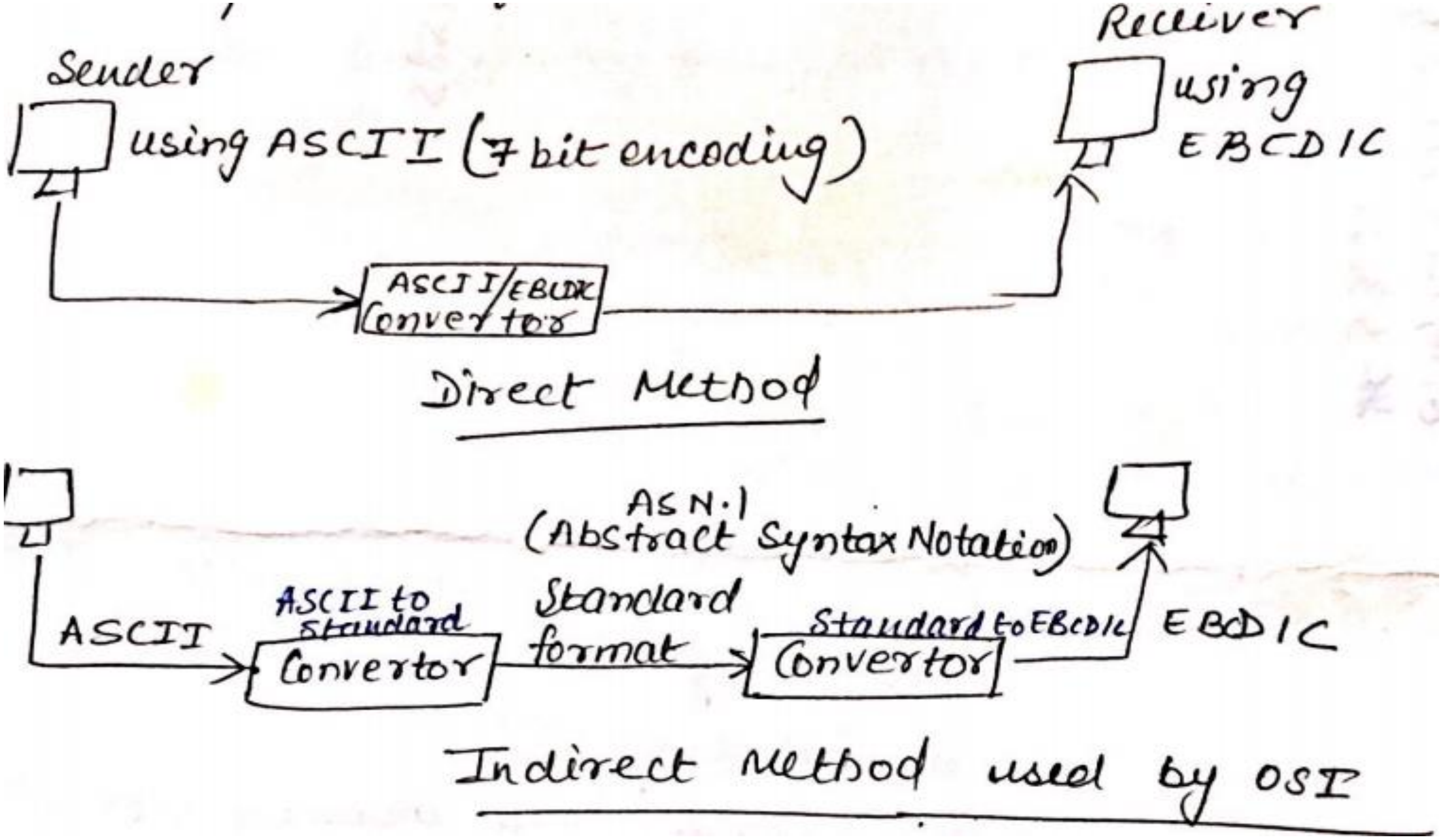


Presentation layer

- Translation
- Network Security

  Encryption /Decryption
- Authentication
- compression

Translation



Sender converts (translate) the data into common format, receiver convert common format data into its own format

Network Security

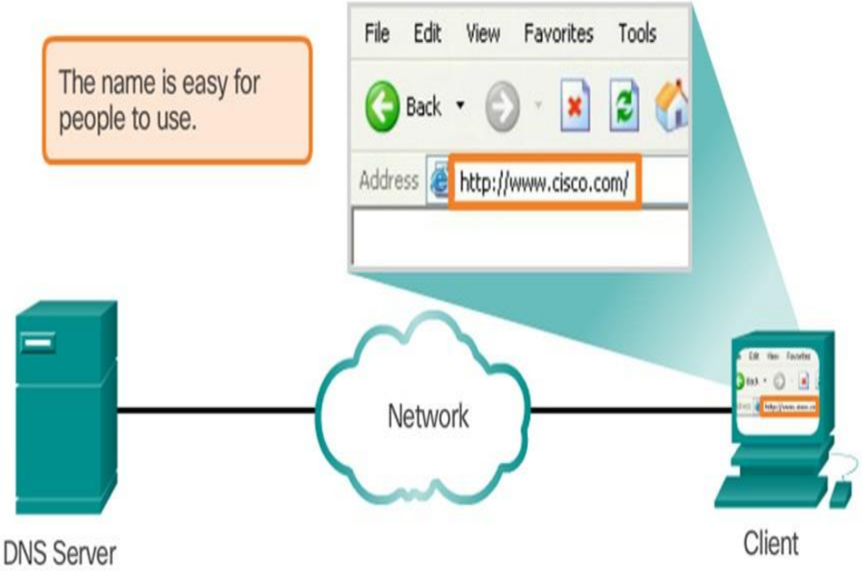
Objective: Study about basic concept of Network security and Cryptography and different types of encryption algorithms

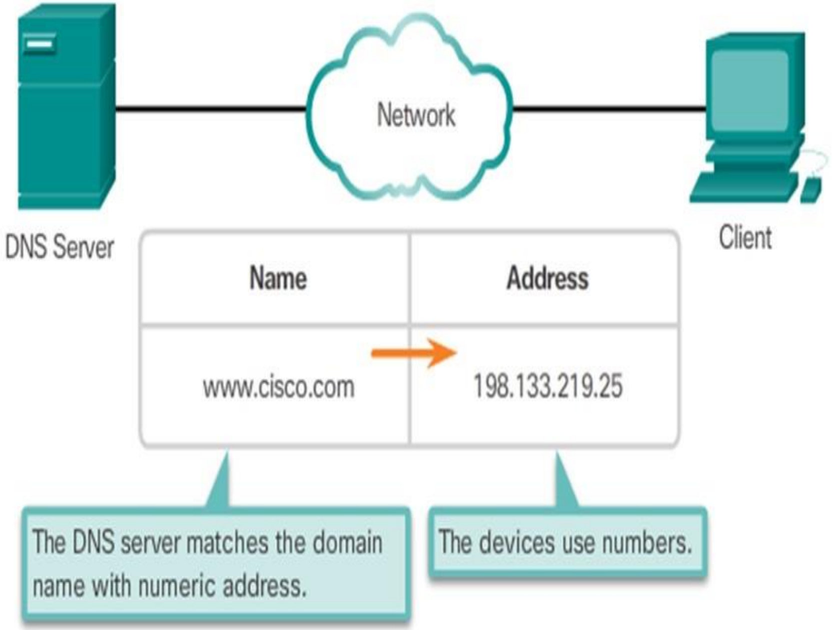
As an asset, information needs to be secured from attacks.

- To be secured, information needs to be hidden from unauthorized access (confidentiality),
- protected from unauthorized change (integrity),
- Available to an authorized entity when it is needed (availability).

Domain name services (DNS)

- While IP addresses are crucial for network communication, they are not easy to memorize.
- Domain names are created to make server addresses more user- friendly.
- Domain names such as http://www.google.com are user-friendly addresses associated with the IP address of a specific server.
- However, computers still need the actual numeric address before they can communicate.


The name is easy for people to use.



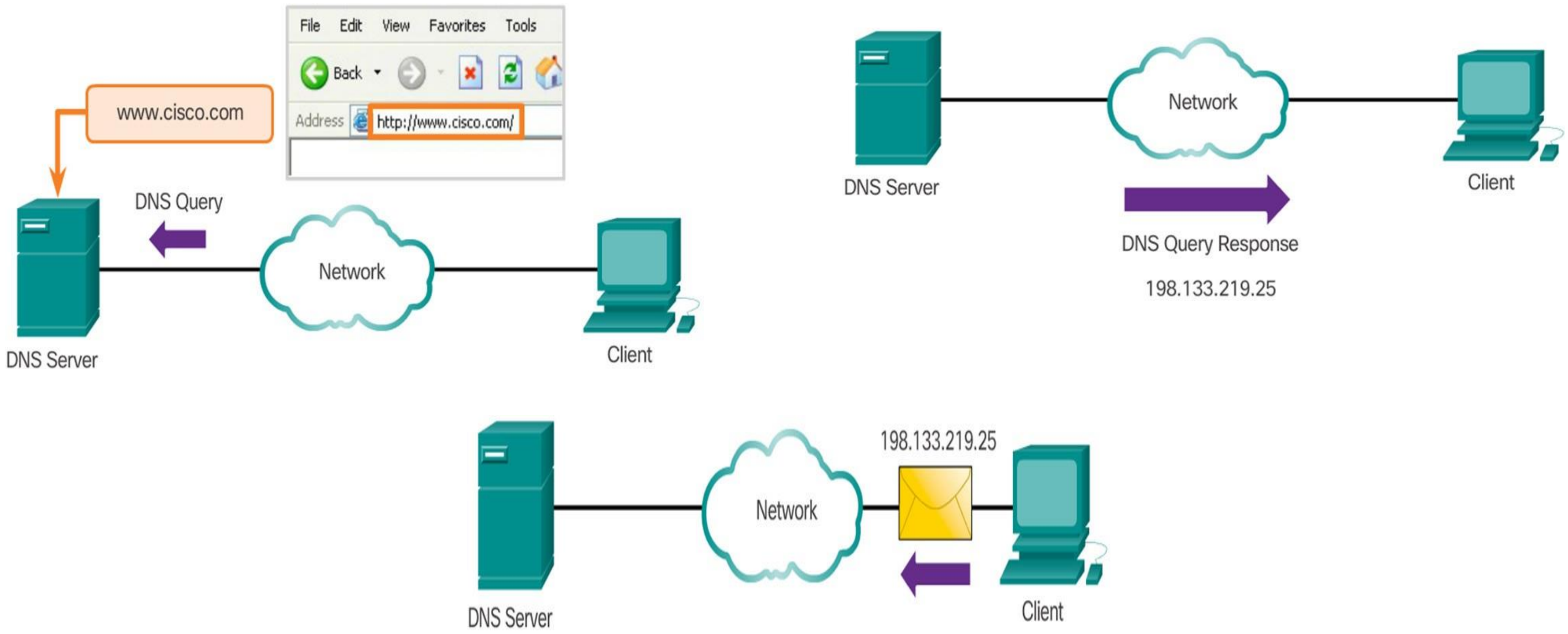
Name	Address
www.cisco.com →	198.133.219.25

The DNS server matches the domain name with numeric address.

The devices use numbers.

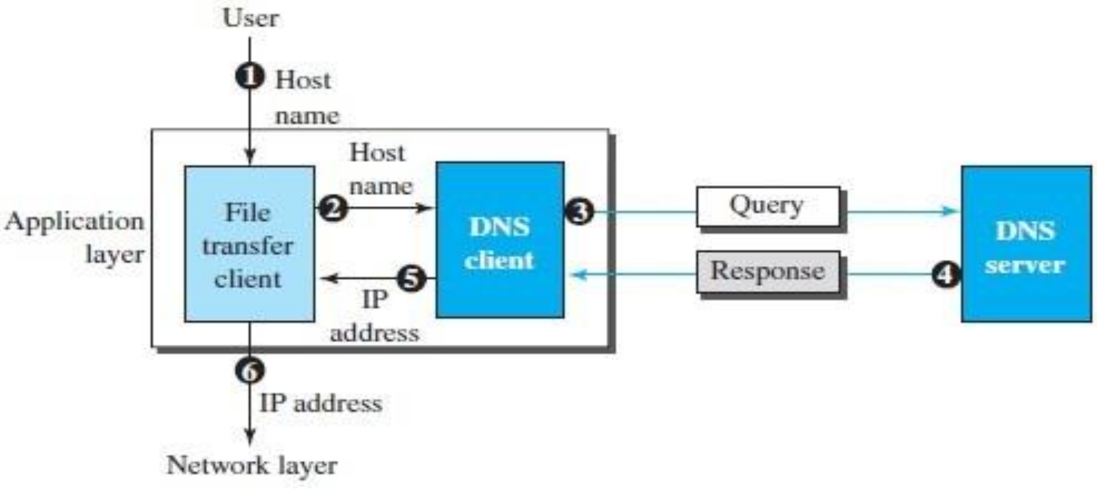
Domain name services

- The DNS protocol allows for the dynamic translation of a domain name into the correct IP address.
- The DNS protocol communications using a single format called a message.



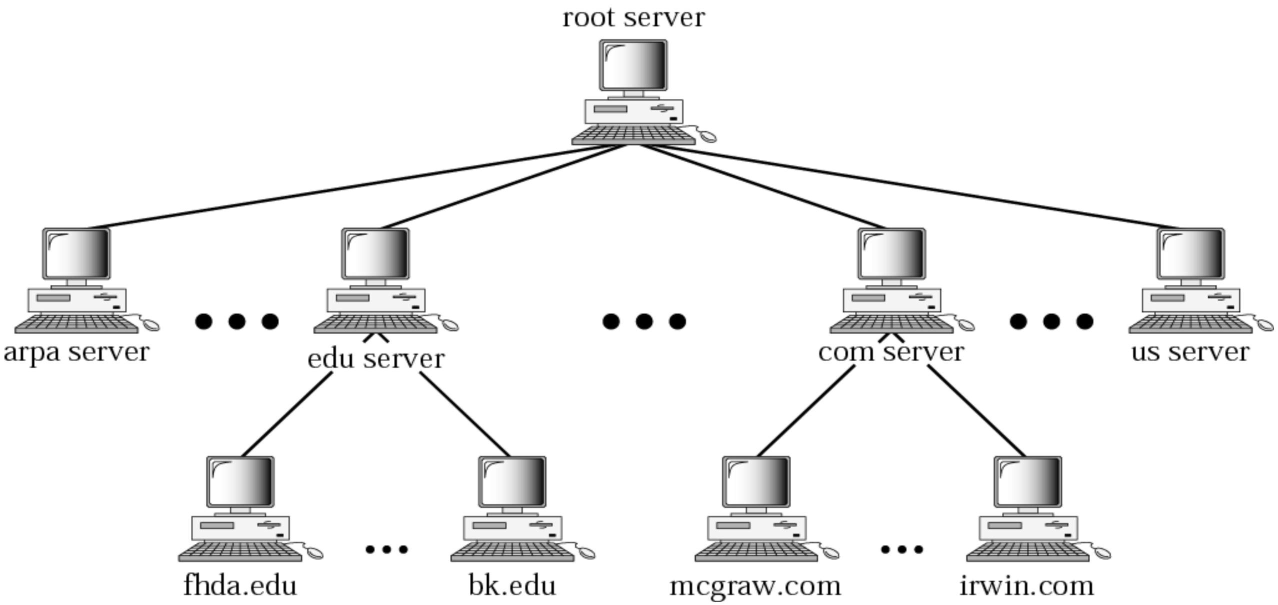
Domain name services

- The user passes the host name to the file transfer client.
- The file transfer client passes the host name to the DNS client.
- Each computer, after being booted, knows the address of one DNS server. The DNS client sends a message to a DNS server with a query that gives the file transfer server name using the known IP address of the DNS server.
- The DNS server responds with the IP address of the desired file transfer server. The DNS server passes the IP address to the file transfer client.
- The file transfer client now uses the received IP address to access the file transfer Server.



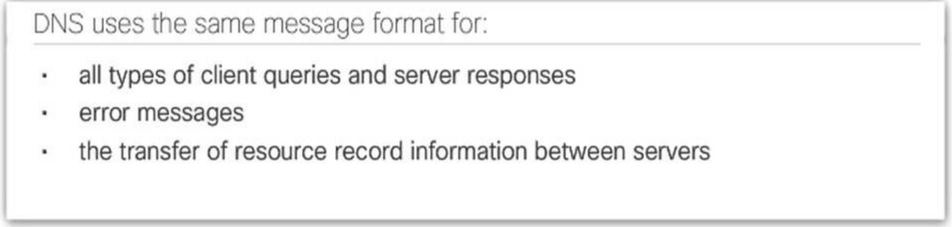
Domain Name Server (DNS)

- Stores domain name space information within its domain/sub- domain.



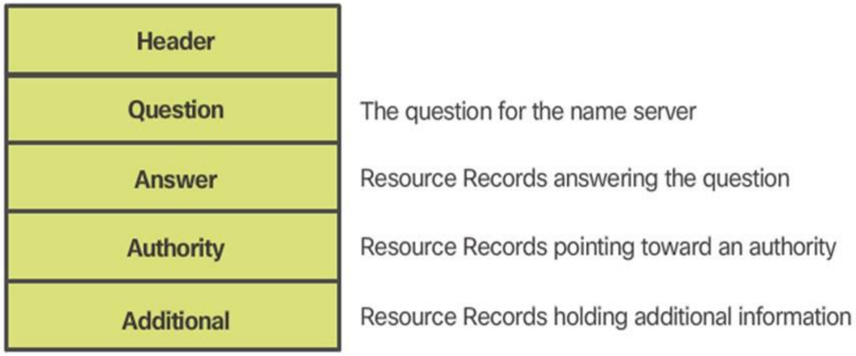
Domain name services

- DNS supports different types of records. Some of these record types are:
  - **A** - An end device IPv4 address
  - **NS** - An authoritative name server
  - **AAAA** - An end device IPv6 address (pronounced quad-A)
  - **MX** - A mail exchange record
- DNS servers will first look at its own records to resolve the name. If the server is unable to resolve the name, it relays the query to other servers.
- The response is then forwarded to the requesting client.
- The DNS Client service on Windows PCs also stores previously resolved names in memory.
- **ipconfig /displaydns** displays all of the cached DNS entries on Windows.



DNS uses the same message format for:

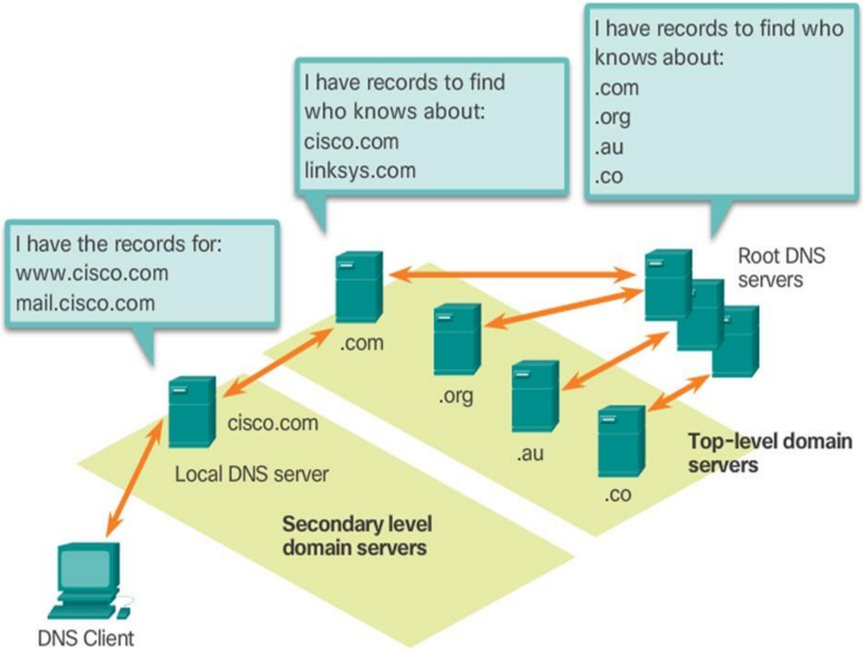
- all types of client queries and server responses
- error messages
- the transfer of resource record information between servers



Header
Question
Answer
Authority
Additional
The question for the name server
Resource Records answering the question
Resource Records pointing toward an authority
Resource Records holding additional information

DNS Hierarchy

- The DNS protocol uses a hierarchical system, with the root at the top and branches below. The naming structure is broken down into small, manageable zones.
- Each DNS server is only responsible for managing name-to-IP mappings for that small portion of the DNS structure.
- Requests for zones not stored in a specific DNS server are forwarded to other servers for translation.
- Top-level domains represent either the type of domain or the country of origin. Examples of top-level domains are:
  - **.com** - a business or industry
  - **.org** - a non-profit organization
  - **.au** - Australia
  - **.co** - Colombia



Working of DNS

1. DNS is a client/server network communication protocol. DNS clients send requests to the server while DNS servers send responses to the client.

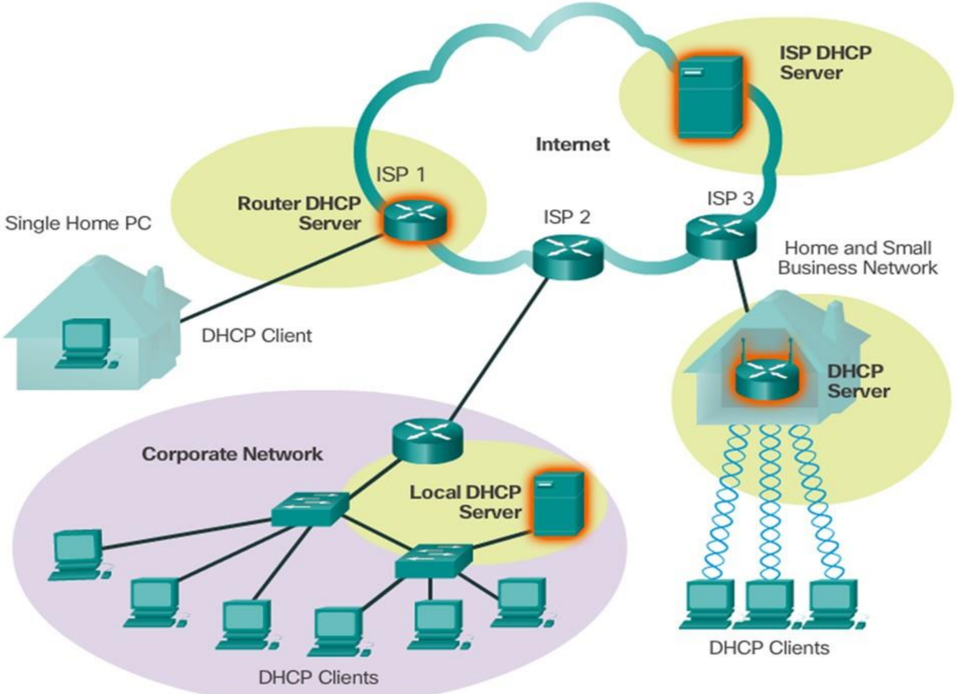
2. Client requests contain a name which is converted into an IP address known as a forward DNS lookups while requests containing an IP address which is converted into a name known as reverse DNS lookups.

3. DNS implements a distributed database to store the name of all the hosts available on the internet.

4. If a client like a web browser sends a request containing a hostname, then a piece of software such as **DNS resolver** sends a request to the DNS server to obtain the IP address of a hostname. If DNS server does not contain the IP address associated with a hostname, then it forwards the request to another DNS server. If IP address has arrived at the resolver, which in turn completes the request over the internet protocol.

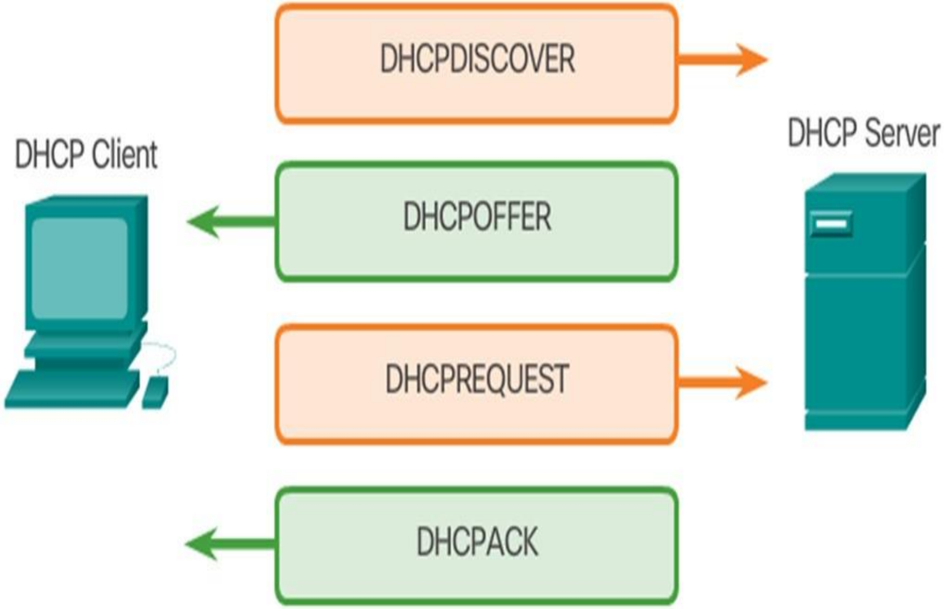
Dynamic Host Configuration Protocol (DHCP)

- Computers need network addresses to communicate over a network.
- Additional crucial information includes gateway address, subnet mask, and DNS server.
- Manually configuring end devices is not scalable. DHCP allows for automated distribution of network information.
- DHCP-distributed addresses are leased for a set period of time.
- Addresses are returned to the pool for reuse when no longer in use.
- DHCP supports IPv4 and DHCPv6 supports IPv6.



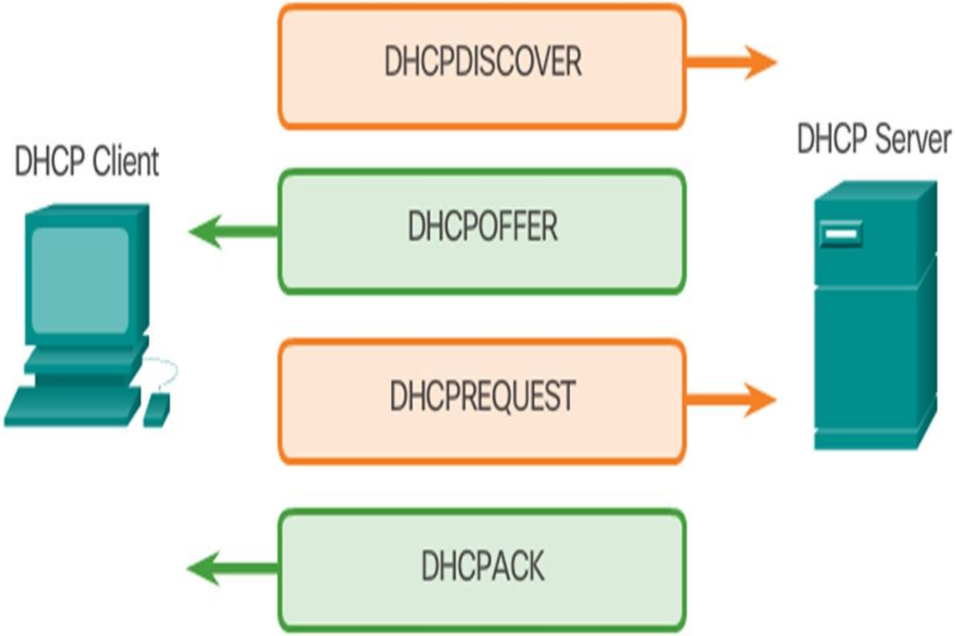
Dynamic Host Configuration Protocol Operation

- A DHCP client goes through the following basic steps to request anIP:
  - The client broadcasts a DHCPDISCOVER.
  - A DHCP server replies with a DHCPOFFER message
  - The client sends a DHCPREQUEST message to the server it wants to use (in case of multiple offers).
- A client may also choose to request an address that it hadpreviously been allocated by the server.
- The server returns a DHCPACK message to confirm the lease has been finalized.



Dynamic Host Configuration Protocol Operation

- The server would respond with a DHCPNAK if the offer is no longer valid
- Leases must be renewed before its expiration through another DHCPREQUEST.
- DHCPv6 has a similar set of messages:
  - SOLICIT
  - ADVERTISE
  - INFORMATION REQUEST
  - REPLY



World Wide Web (WWW)

The World Wide Web (WWW) operates primarily at the application layer of the Internet protocol suite. This layer is responsible for providing network services directly to end-users or applications. Here's how the WWW operates within the application layer:

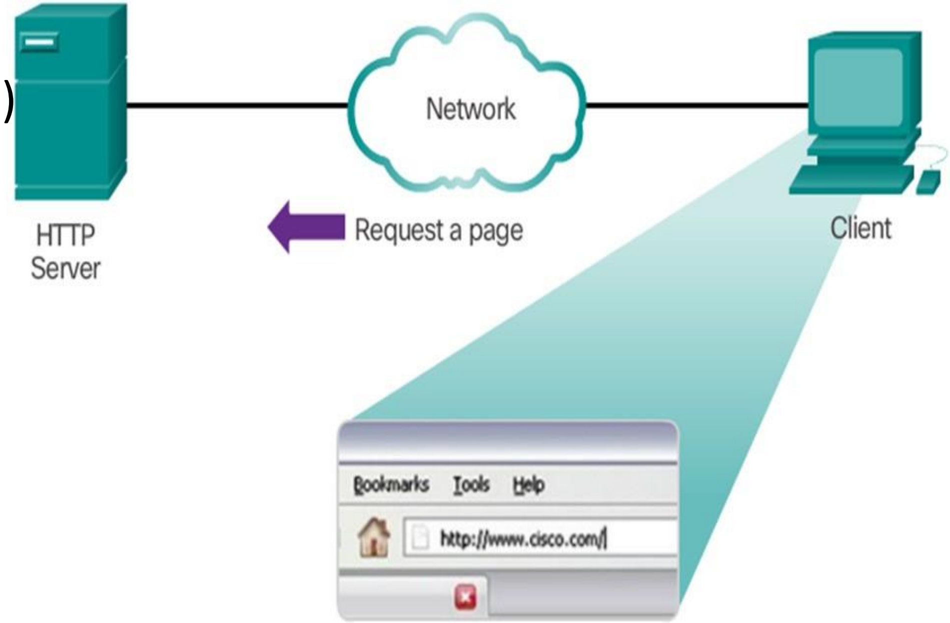
- **HTTP Protocol**
- **Web Browsers**
- **Web Servers**
- **Uniform Resource Locators (URLs)**
- **HTML, CSS, and JavaScript**
- **Hyperlinks**

Hypertext transfer protocol and markup language

- A web address or uniform resource locator (URL) is a reference to a web server. A URL allows a web browser to establish a connection to that web server.
- URLs and Uniform Resource Identifier (URIs) are the names most people associate with web addresses.
- The URL http://google.com/index.html has three basic parts:

HTTP Protocol Step 1

- **http** (the protocol or scheme)
- www.gogle.com (the server name)
- **index.html** (the specific filename requested)

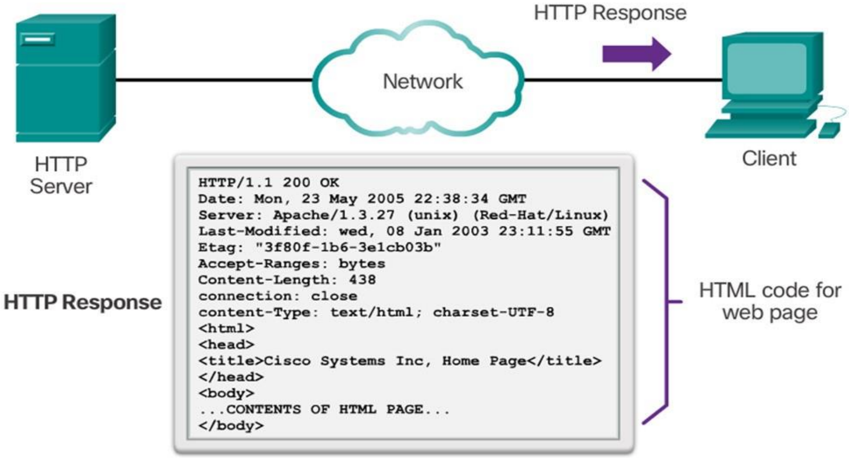


- Using DNS, the server name portion of the URL is then translated to the associated IP address before the server can be contacted.

Hypertext transfer protocol and markup language

HTTP Protocol Step 2

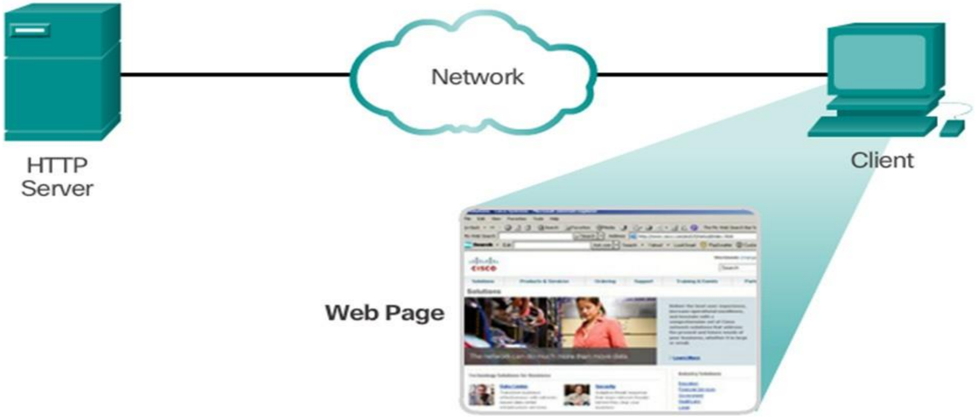
- The browser sends a GET request to the server’s IP address and asks for the **index.html** file.
- The server sends the requested file to the client.
- The **index.html** was specified in the URL and contains the HTML code for this web page.



```
HTTP/1.1 200 OK
Date: Mon, 23 May 2005 22:38:34 GMT
Server: Apache/1.3.27 (unix) (Red-Hat/Linux)
Last-Modified: wed, 08 Jan 2003 23:11:55 GMT
Etag: "3f80f-1b6-3e1cb03b"
Accept-Ranges: bytes
Content-Length: 438
connection: close
content-Type: text/html; charset-UTF-8
<html>
<head>
<title>Cisco Systems Inc, Home Page</title>
</head>
<body>
...CONTENTS OF HTML PAGE...
</body>
```

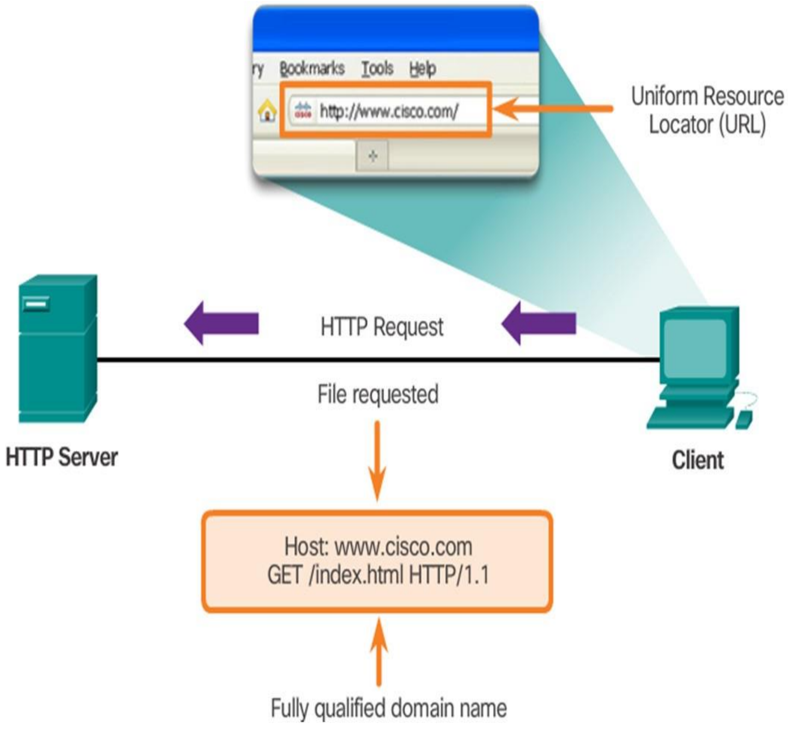
HTTP Protocol Step 3

- The browser processes the HTML code and formats the page for the browser window based on the code in the file.

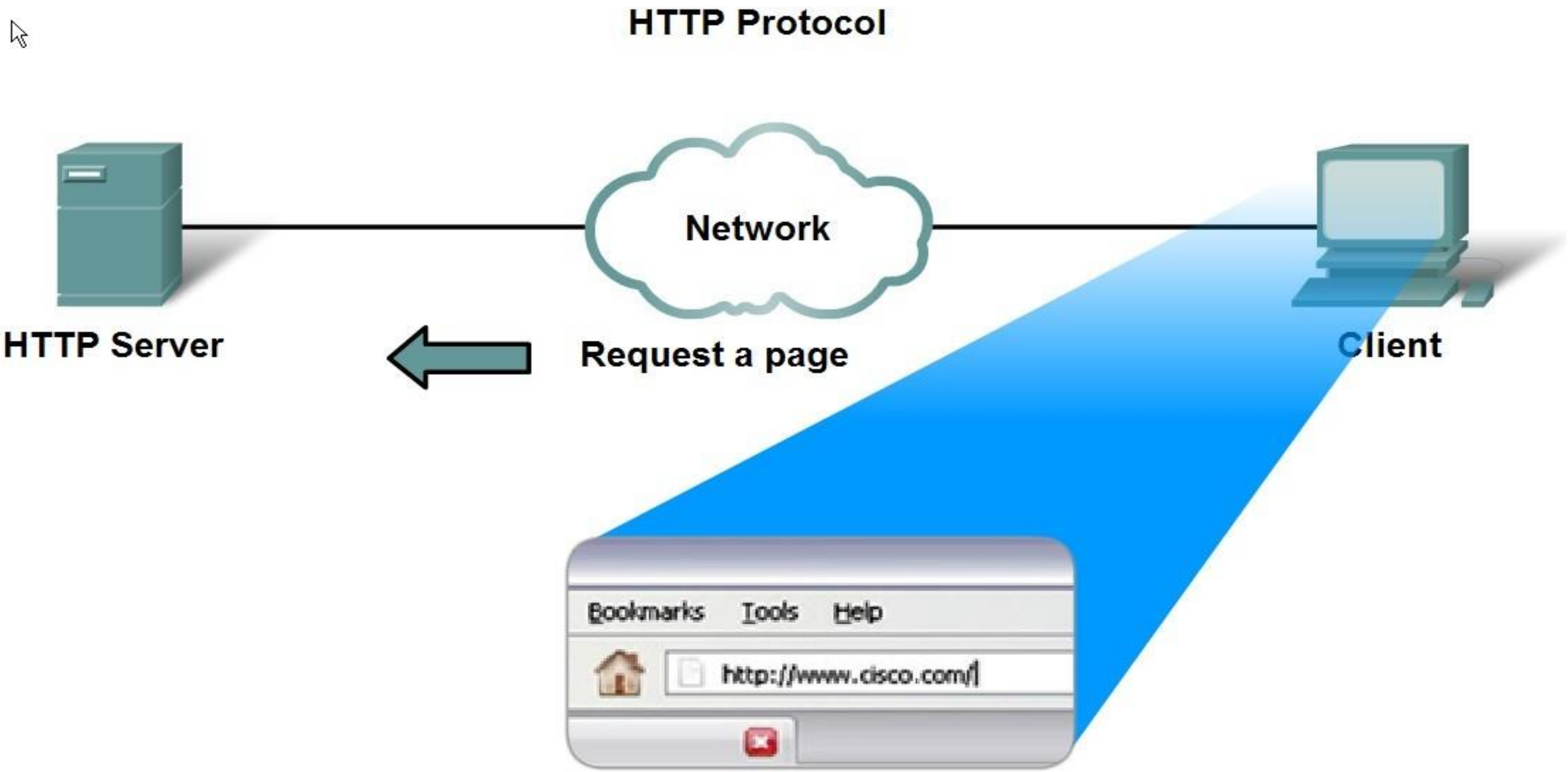


Hypertext transfer protocol

- HTTP
  - Is a request/response protocol.
  - Has three common message types: GET, POST, PUT.
  - Is not secure. Messages can be intercepted.
- HTTPS uses authentication and encryption to secure data.

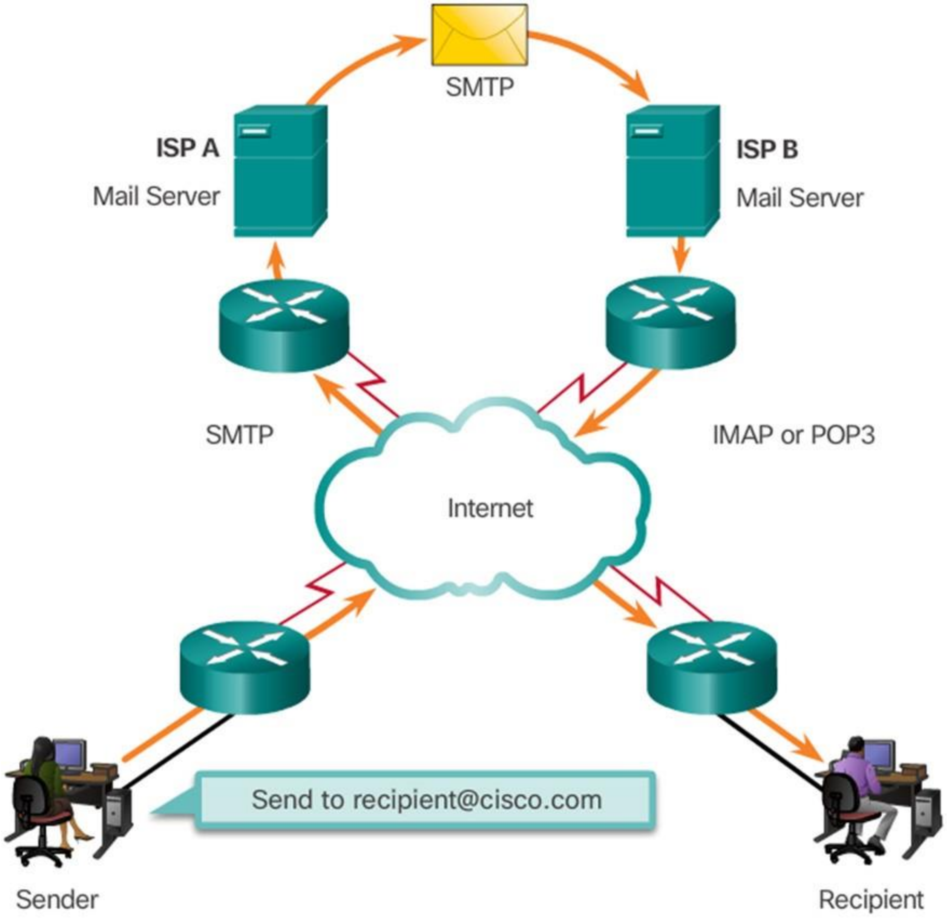


WWW services and HTTP



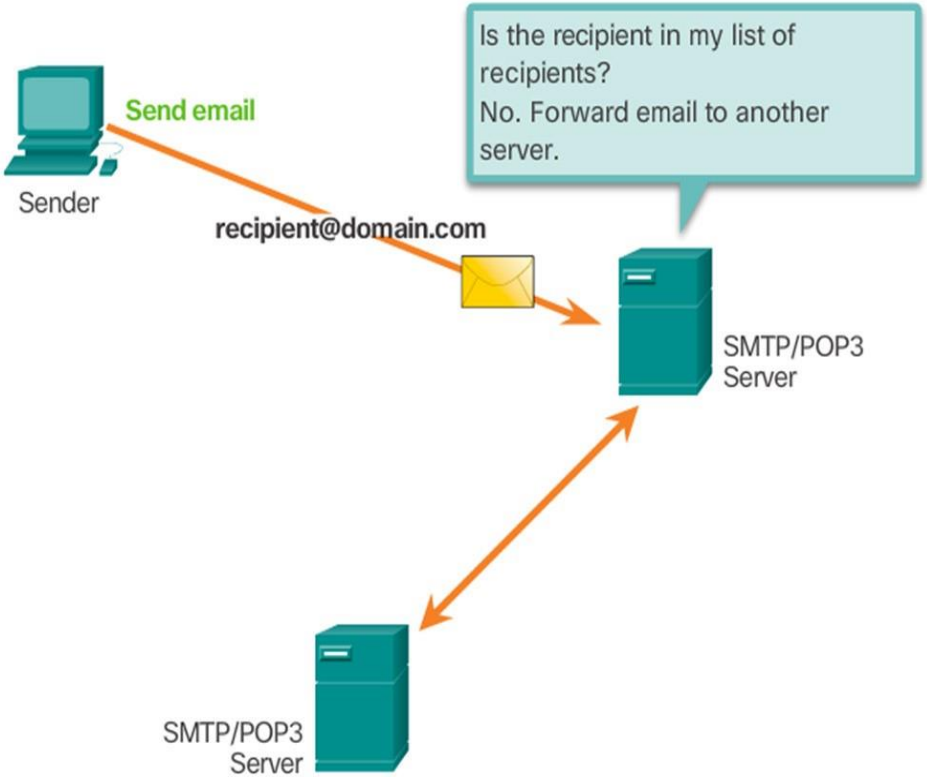
Email Protocols

- Email is a store-and-forward method of sending, storing, and retrieving electronic messages.
- Email messages are stored in databases on mail servers.
- Email clients communicate with mail servers to send and receive email.
- Mail servers communicate with other mail servers to transport messages from one domain to another.
- Email clients do not communicate directly when sending email.
- Email relies on three separate protocols for operation:
  SMTP (sending),
  POP (retrieving),
  IMAP (retrieving).



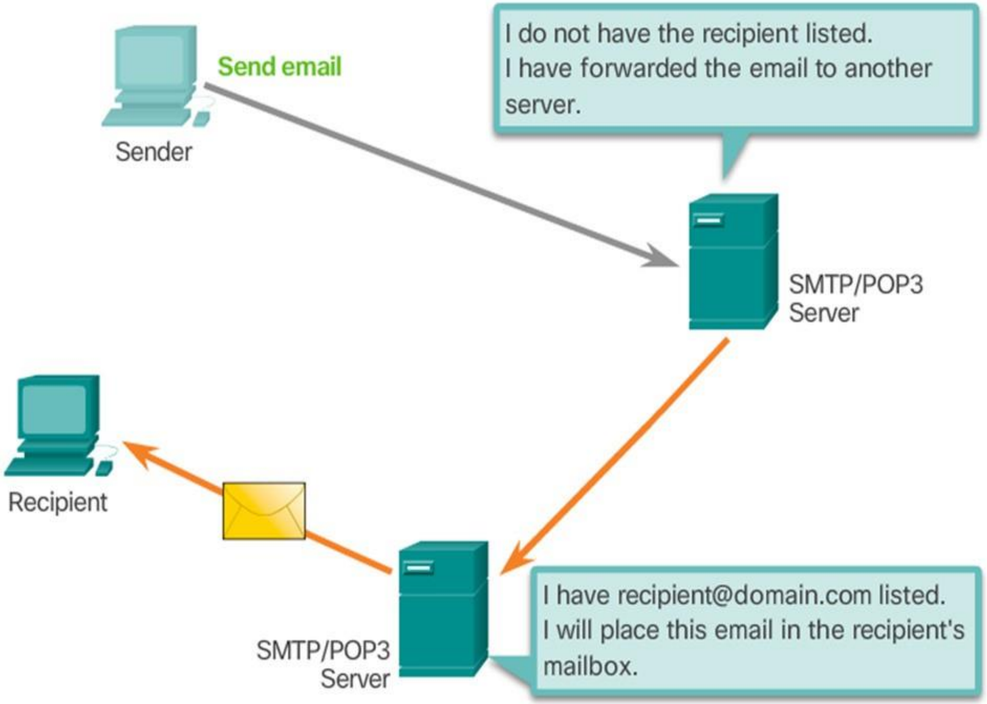
SMTP (Simple Mail Transfer Protocol) Operation

- SMTP message formats require a message header and body.
- The body can contain any amount of text.
- The header must have a properly formatted recipient email address and a sender address.
- An SMTP client sends an email by connecting to a SMTP server on port 25.
- The server receives the message and stores it message in a local mailbox or relays the message to another mail server.
- Users use email clients to retrieve messages stored on the server.
- IMAP and POP are two protocols commonly used by email clients to retrieve messages.


Is the recipient in my list of recipients?
No. Forward email to another server.
Send email
Sender
recipient@domain.com
SMTP/POP3 Server
SMTP/POP3 Server

POP (post office protocol) Operation

- Messages are downloaded from the server to the client.
- The server listens on port 110 TCP for client requests.
- Email clients direct their POP requests to mail servers on port TCP 110.
- The POP client and server exchange commands and responses until the connection is closed or aborted.
- POP allows for email messages to be downloaded to the client's device (computer or phone) and removed from the server.
- There is no centralized location where email messages are kept.
- A downloaded message resides on the device that triggered the download.

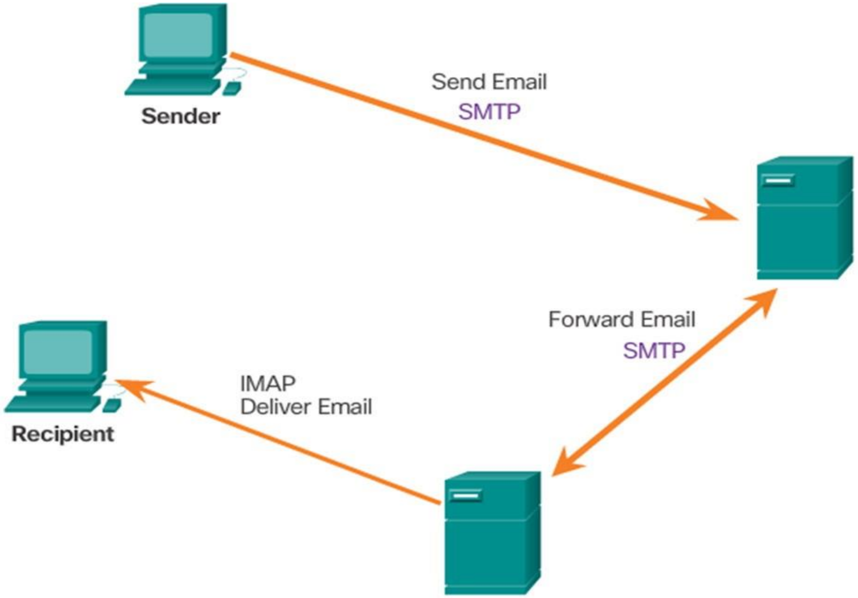


I do not have the recipient listed.
I have forwarded the email to another server.

I have recipient@domain.com listed.
I will place this email in the recipient's mailbox.

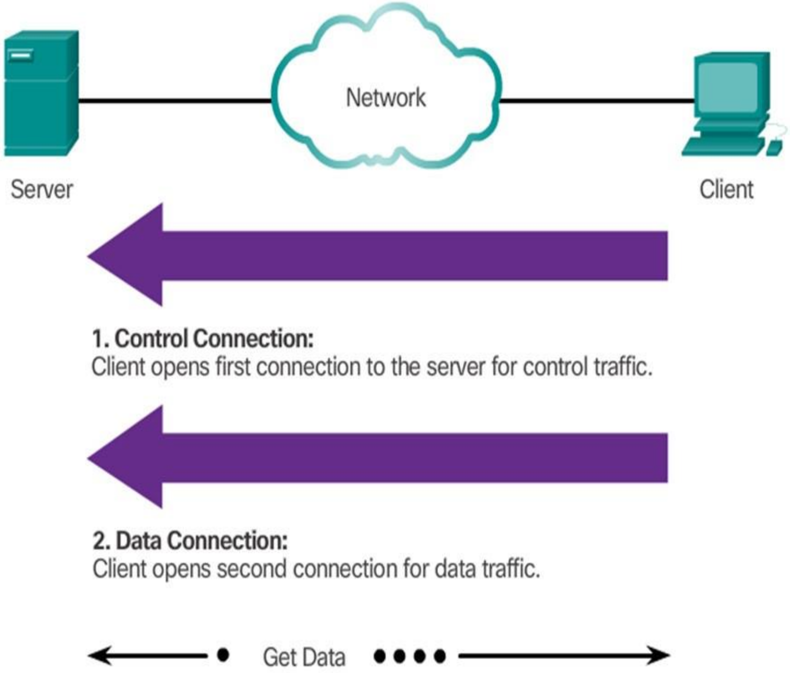
IMAP (Internet Message Access **Protocol**) Operation

- IMAP is another protocol used to retrieve email messages.
- Allows for messages to be displayed to the user rather than downloaded.
- The original messages reside on the server until manually deleted by the user.
- Users view copies of the messages in their email client software.
- Users can create a folder hierarchy on the server to organize and store mail.
- That file structure is displayed on the email client.
- When a user decides to delete a message, the server synchronizes that action and deletes the message from the server.



File transfer Protocol(FTP)

- FTP was developed to allow the transfer of files over the network.
- An FTP client is an application that runs on a client computer used to push and pull data from an FTP server.
- FTP requires two connections between the client and the server: one connection for commands and replies and another connection for the actual file transfer.
- The client initiates and establishes the first connection to the server for control traffic on TCP port 21.
- The client then establishes the second connection to the server for the actual data transfer on TCP port 20.
- The client can download (pull) data from the server or upload (push) data to the server



1. Control Connection:
Client opens first connection to the server for control traffic.

2. Data Connection:
Client opens second connection for data traffic.

E-Mail (CO5)

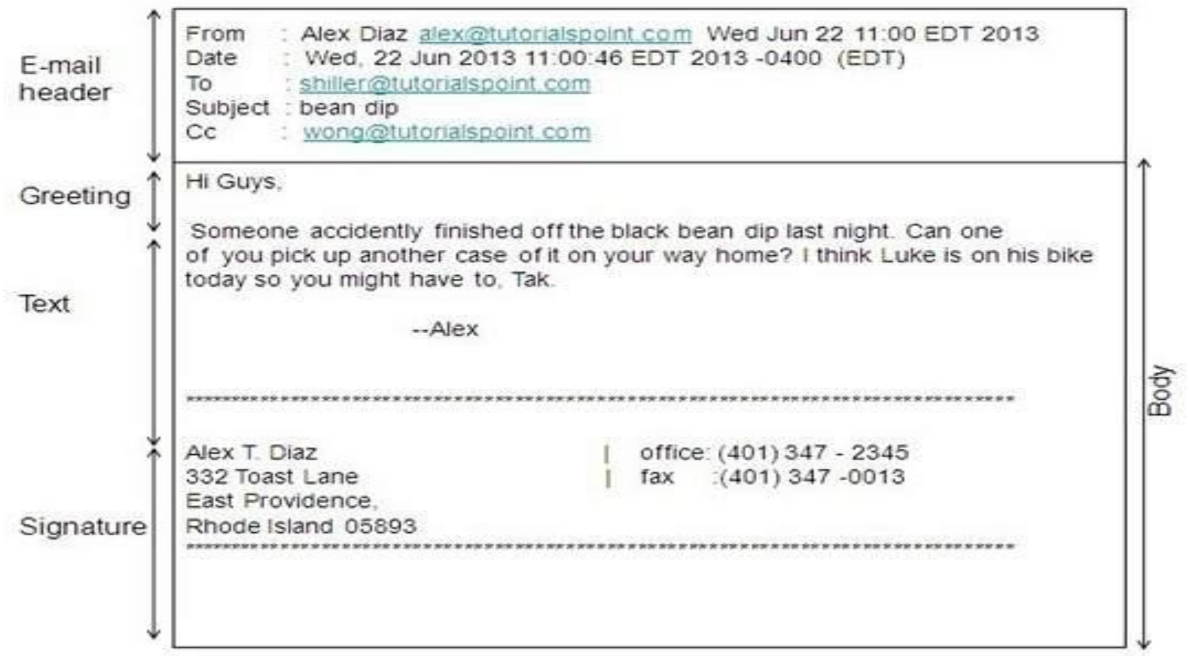
- Email is a service which allows us to send the message in electronic mode over the internet. It offers an efficient, inexpensive and real time mean of distributing information among people.

E-Mail Address:

- Each user of email is assigned a unique name for his email account. This name is known as E-mail address. Different users can send and receive messages according to the e-mail address. E-Mail is generally of the form username@domainname. For example, webmaster@tutorialspoint.com is an email address where webmaster is username and tutorialspoint is domain name.
- E-mail is the username and the domain name are separated by **@ (at)** symbol.
- E-mail addresses are not case sensitive.
- Spaces are not allowed in e-mail address.

E-Mail(CO5)

- **E-mail Message Components :** E-mail message comprises of different components: E-mail Header, Greeting, Text, and Signature. These components are described in the following diagram:



From : Alex Diaz alex@tutorialspoint.com Wed Jun 22 11:00 EDT 2013
Date : Wed, 22 Jun 2013 11:00:46 EDT 2013 -0400 (EDT)
To : shiller@tutorialspoint.com
Subject : bean dip
Cc : wong@tutorialspoint.com

Hi Guys,

Someone accidently finished off the black bean dip last night. Can one of you pick up another case of it on your way home? I think Luke is on his bike today so you might have to, Tak.

--Alex

****

Alex T. Diaz | office: (401) 347 - 2345
332 Toast Lane | fax :(401) 347 -0013
East Providence,
Rhode Island 05893

****

E-Mail(CO5)

- **E-mail Header**

The first five lines of an E-mail message is called E-mail header. The header part comprises of following fields:

From

Date

To

Subject

CC

BCC

E-Mail(CO5)

Advantages: E-mail has proved to be powerful and reliable medium of communication. Here are the benefits of E-mail:

- Reliable: Many of the mail systems notify the sender if e-mail message was undeliverable
- Convenience: There is no requirement of stationary and stamps. One does not have to go to post office. But all these things are not required for sending or receiving an mail.
- Speed: E-mail is very fast. However, the speed also depends upon the underlying network
- Inexpensive: The cost of sending e-mail is very low.
- Printable: It is easy to obtain a hardcopy of an e-mail. Also an electronic copy of an e-mail can also be saved for records.
- Global: E-mail can be sent and received by a person sitting across the globe.

E-Mail(CO5)

Disadvantages : Apart from several benefits of E-mail, there also exists some disadvantages as discussed below:

- Forgery: E-mail doesn’t prevent from forgery, that is, someone impersonating the sender, since sender is usually not authenticated in any way.
- Overload: Convenience of E-mail may result in a flood of mail.
- Misdirection: It is possible that you may send e-mail to an unintended recipient.
- Junk: Junk emails are undesirable and inappropriate emails. Junk emails are sometimes referred to as spam.
- No Response: It may be frustrating when the recipient does not read the e-mail and respond on a regular basis

E-Mail protocols(CO5)

IMAP: IMAP stands for Internet Mail Access Protocol. It was first proposed in 1986. There exist five versions of IMAP as follows:

- Original IMAP
- IMAP2
- IMAP3
- IMAP2bis
- IMAP4

Key Points:

- IMAP allows the client program to manipulate the e-mail message on the server without downloading them on the local computer.
- The e-mail is hold and maintained by the remote server.

E-Mail protocols(CO5)

POP:

- POP stands for Post Office Protocol. It is generally used to support a single client. There are several versions of POP but the POP 3 is the current standard.

Key Points

- POP is an application layer internet standard protocol.
- Since POP supports offline access to the messages, thus requires less internet usage time.
- POP does not allow search facility.
- In order to access the messaged, it is necessary to download them.
- It allows only one mailbox to be created on server.
- It is not suitable for accessing non mail data

E-mail System(CO5)

- E-mail system comprises of the following three components:
- Mailer: It is also called mail program, mail application or mail client. It allows us to manage, read and compose e-mail.
- Mail Server: The function of mail server is to receive, store and deliver the email. It is must for mail servers to be running all the time because if it crashes or is down, email can be lost.
- Mailboxes: Mailbox is generally a folder that contains emails and information about them.

Working of E-mail(CO5)

Email working follows the client server approach. In this client is the mailer i.e. the mail application or mail program and server is a device that manages emails.

Following example will take you through the basic steps involved in sending and receiving emails and will give you a better understanding of working of email system:

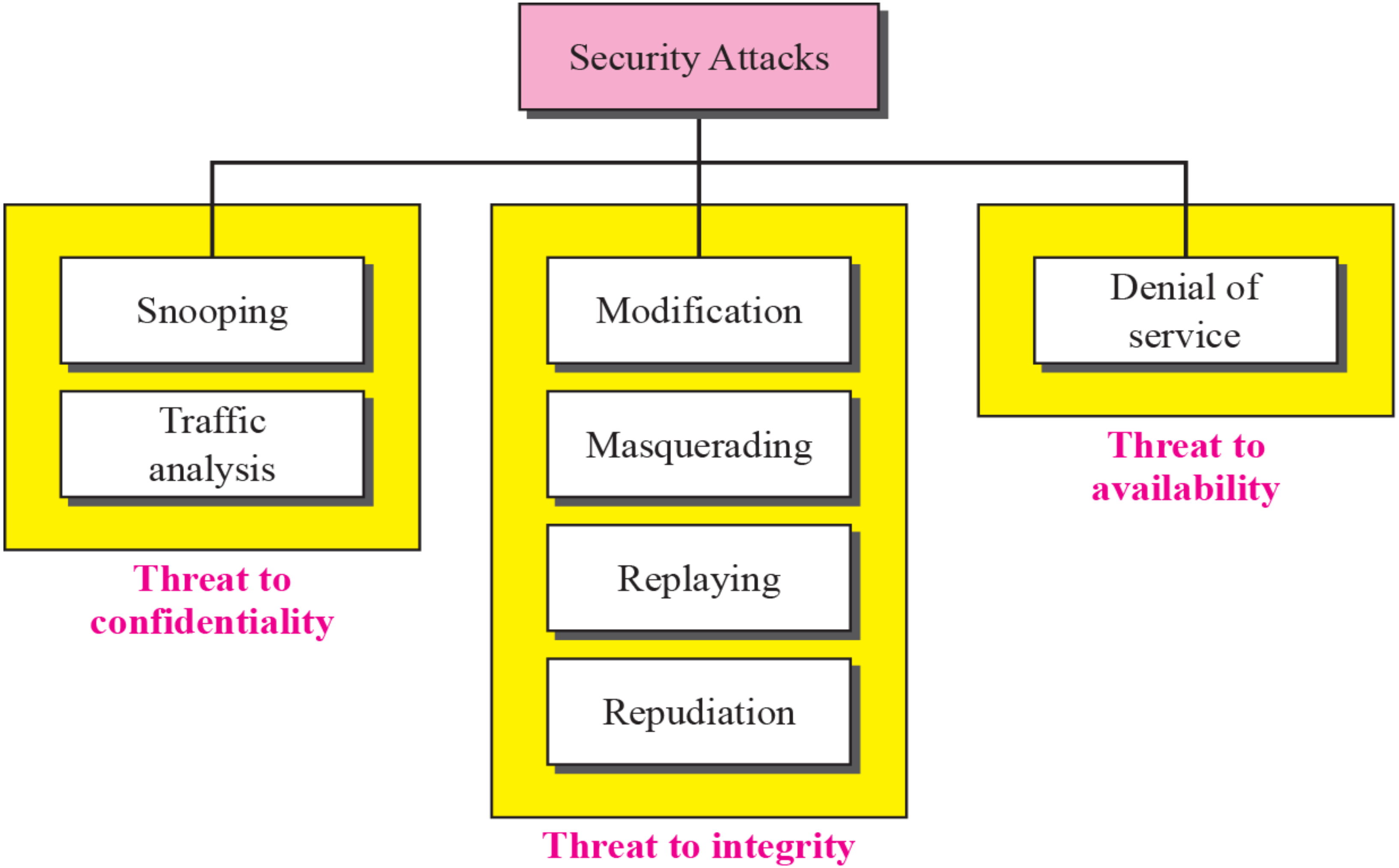
- Suppose person A wants to send an email message to person B.
- Person A composes the messages using a mailer program i.e. mail client and then select Send option.
- The message is routed to Simple Mail Transfer Protocol to person B's mail server.
- The mail server stores the email message on disk in an area designated for person B.

Remote login

Remote login, also known as remote access, allows users to access and interact with a computer or network from a remote location. This functionality operates primarily at the application layer of the OSI model. Here's how remote login works at the application layer:

- Protocols
- Client-Server Communication
- Authentication
- Session Establishment
- Data Transmission
- Encryption
- Session Termination

Attacks with relation to security goals



Attacks

Snooping : in a security context, is unauthorized access to another person's or company's data.

The practice is similar to eavesdropping but is not necessarily limited to gaining access to data during its transmission.

Traffic analysis :
Traffic analysis is the process of intercepting and examining messages in order to deduce information from patterns in communication, which can be performed even when the messages are encrypted.
Eg. Military Intelligence

Masquerade : means "to pretend to be someone else.“
A masquerade attack is an attack that uses a fake identity, such as a network identity, to gain unauthorized access to personal computer information through legitimate access identification.

Attacks

Replaying:

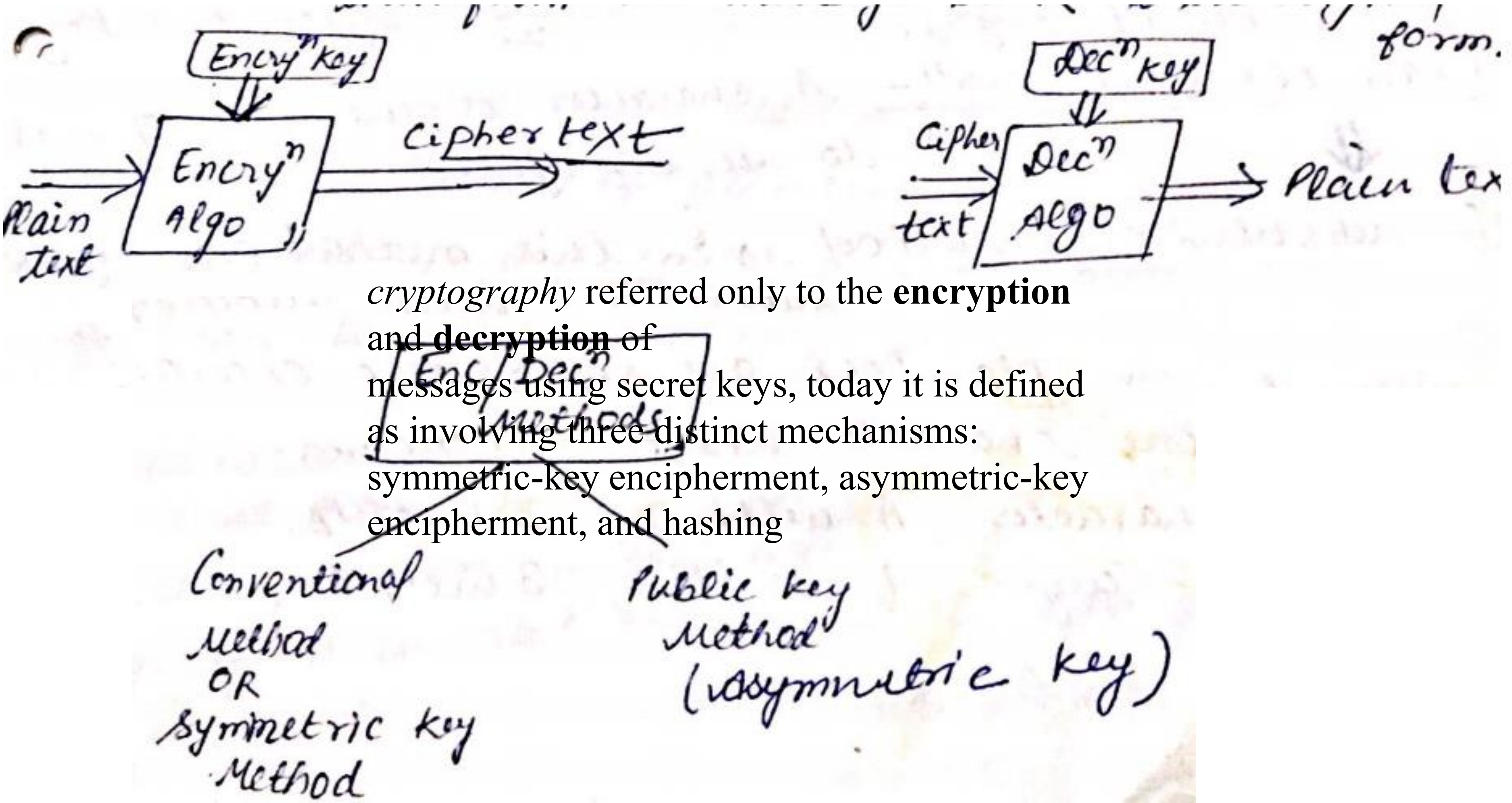
Replay attacks are the network attacks in which an attacker spies the conversation between the sender and receiver and takes the authenticated information e.g. sharing key and then contact to the receiver with that key.

A repudiation attack occurs when the user denies the fact that he or she has performed a certain action or has initiated a transaction. ... The attacker plans to gain easy access to a computer system and gain control

(DoS)Denial of service:

In computing, a denial-of-service attack (DoS attack) is a cyber-attack in which the perpetrator seeks to make a machine or network resource unavailable to its intended users by temporarily or indefinitely disrupting services of a host connected to the Internet.

Network security : Encryption/ Decryption



cryptography referred only to the **encryption** and **decryption** of messages using secret keys, today it is defined as involving three distinct mechanisms: symmetric-key encipherment, asymmetric-key encipherment, and hashing

Network security : Encryption/ Decryption

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symmetric-key encipherment,
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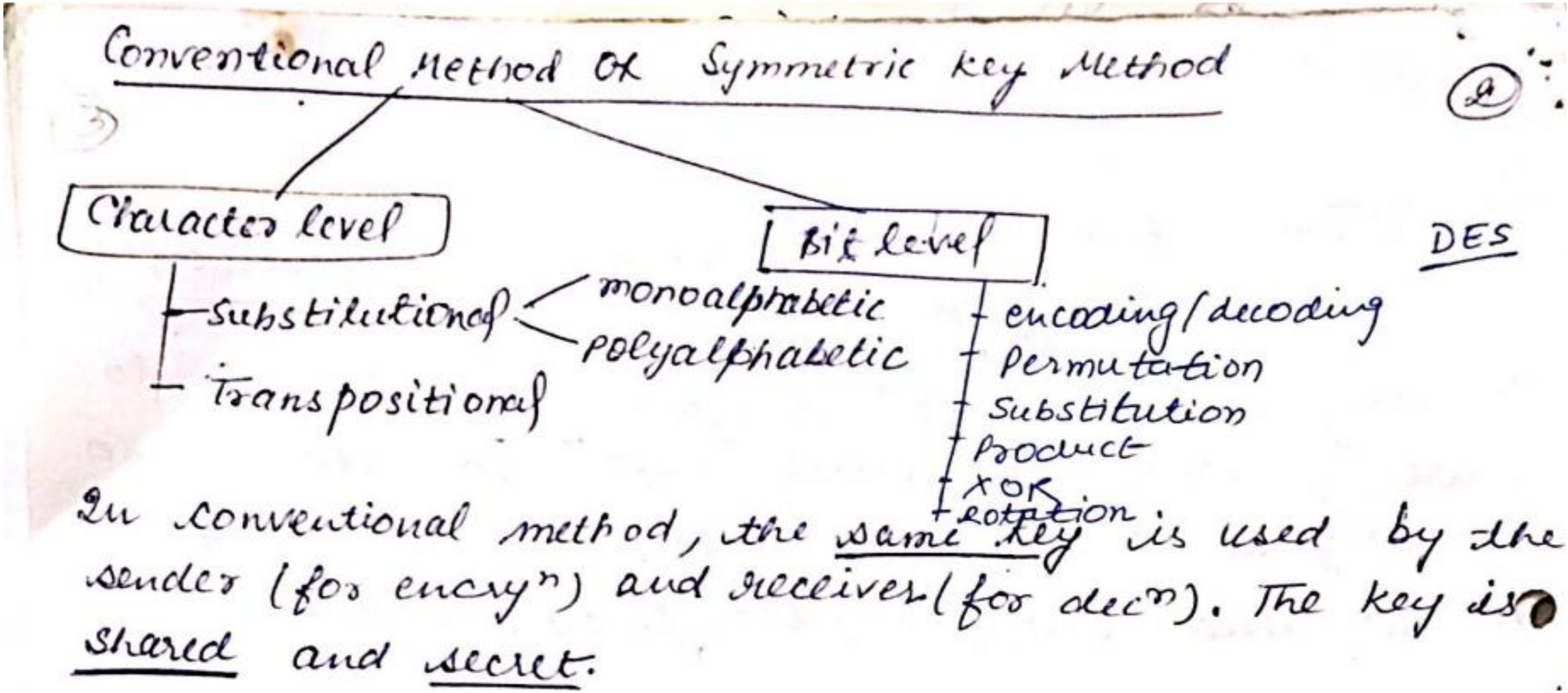
Encryption/ Decryption Methods



Conventional Method Or Symmetric key Method

2

- Character level
  - Substitutional
    - monoalphabetic
    - polyalphabetic
  - Transpositional
- Bit level
  - encoding/decoding
  - Permutation
  - Substitution
  - Product
  - XOR
  - rotation

DES

In conventional method, the same key is used by the sender (for encry^n) and receiver (for dec^n). The key is shared and secret.

TRADITIONAL CIPHERS

Ciphers: secret writing

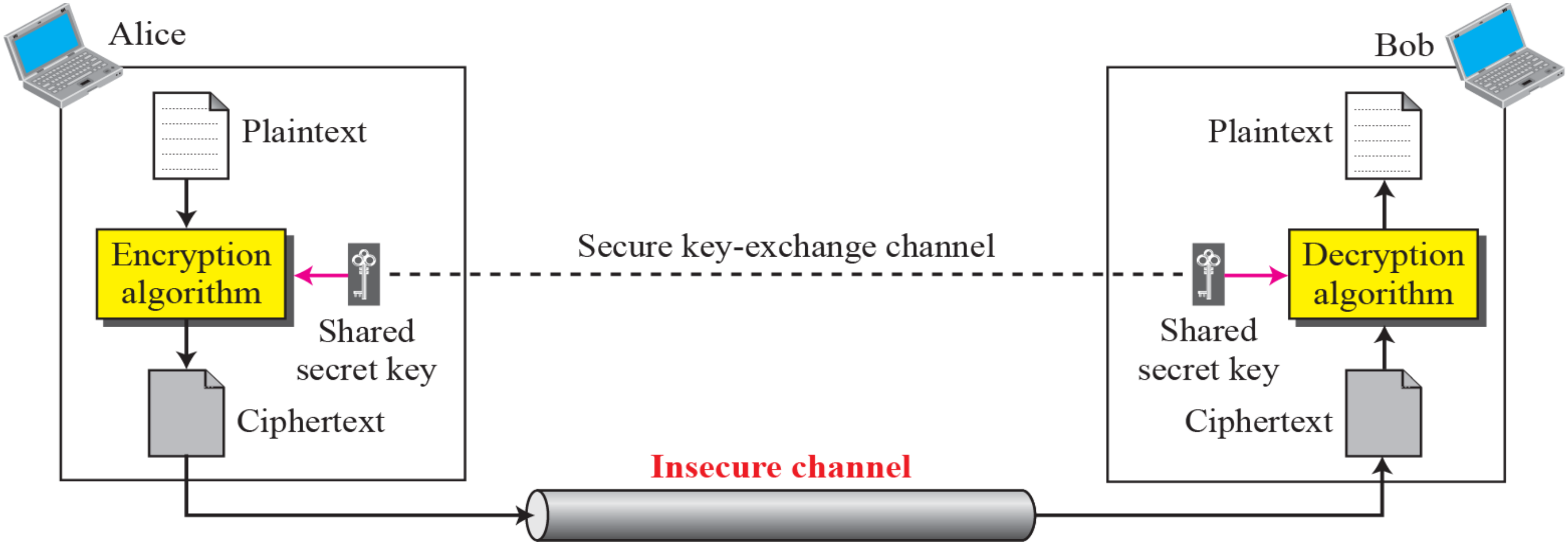
Cryptography : process of secret writing

first goal of security is confidentiality
Confidentiality can be achieved using ciphers.

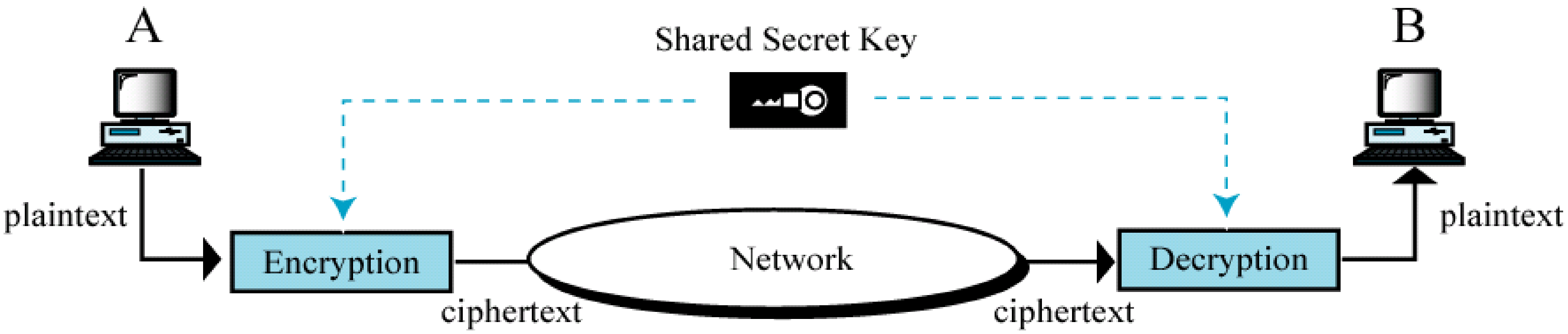
Encryption: converting original msg to cipher msg so that can not be understand by any other. (at the sender side)

Decryption : converting cipher msg to original msg (at the receiver side)

General idea of traditional cipher

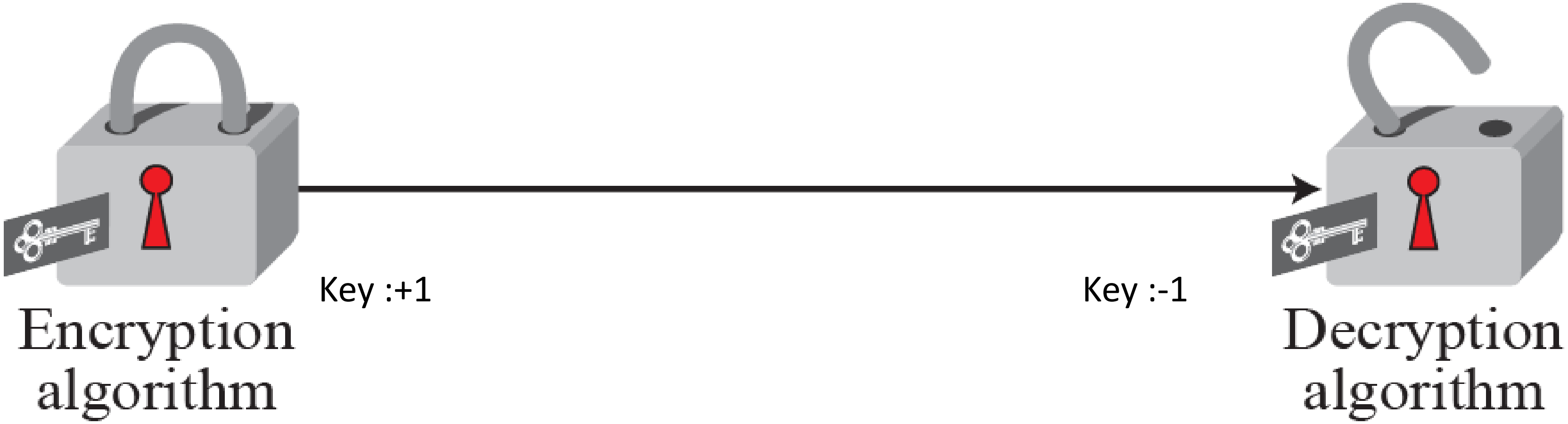


Secret key encryption/ symmetric Key



Symmetric-key: substitution Method

locking and unlocking with the same key



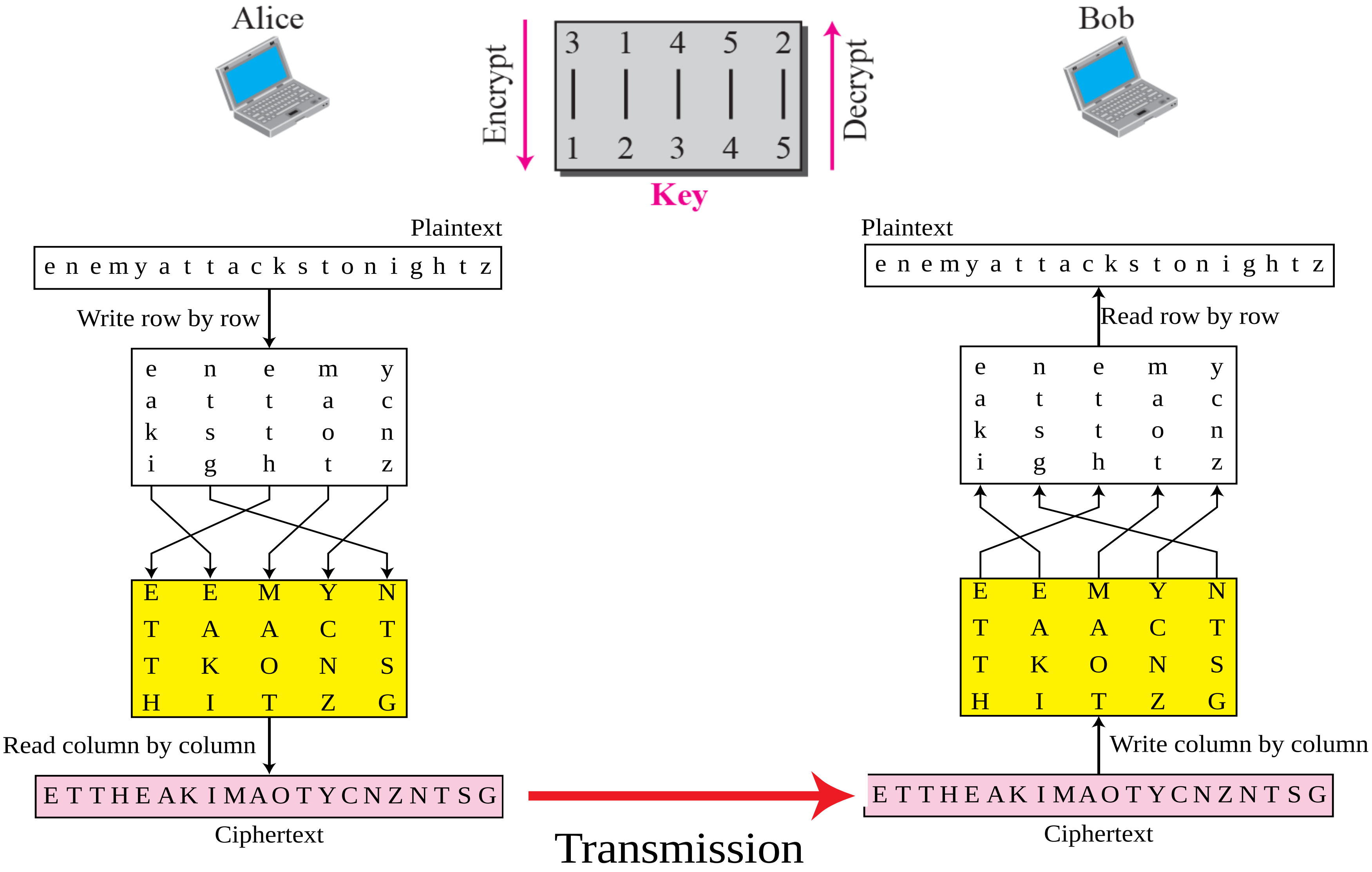
A substitution cipher replaces one symbol

Original msg: HELLO

Cypher msg: IFMMP

Key : 1

Symmetric-key: Transposition cipher



Plaintext: e n e m y a t t a c k s t o n i g h t z

e	n	e	m	y
a	t	t	a	c
k	s	t	o	n
i	g	h	t	z

E	E	M	Y	N
T	A	A	C	T
T	K	O	N	S
H	I	T	Z	G

Ciphertext: E T T H E A K I M A O T Y C N Z N T S G

Asymmetric-key

In asymmetric-key cryptography, the secret is personal (unshared); each person creates and keeps his or her own secret.

In a community of *n* people, *n* (*n* – 1)/2 shared secrets are needed for symmetric key cryptography; only *n* personal secrets are needed in asymmetric-key cryptography.

Whenever an application is based on a personal secret, we need to use asymmetric-key cryptography.

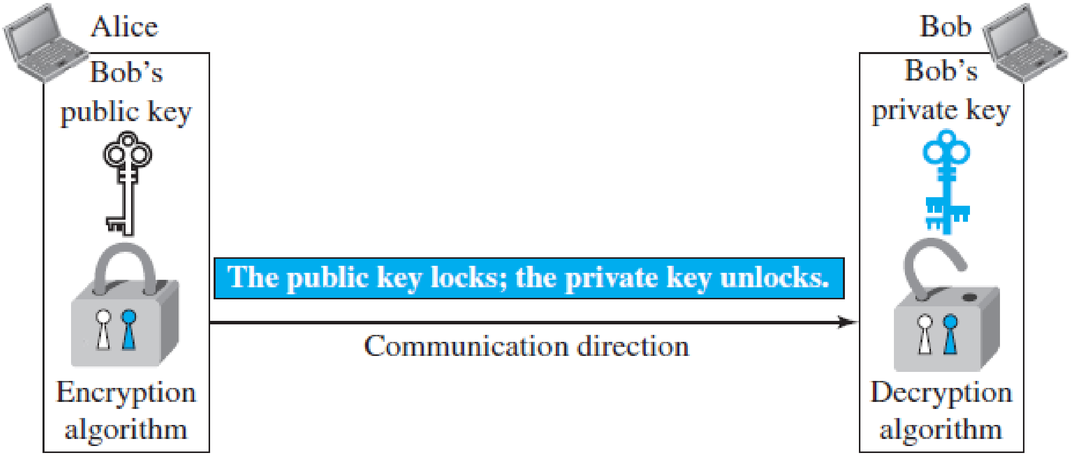
Whereas symmetric-key cryptography is based on substitution and permutation of symbols (characters or bits), asymmetric-key cryptography is based on applying mathematical functions to numbers.

Asymmetric key cryptography uses two separate keys: one private and one public.

Asymmetric-key cryptography is normally used to encrypt or decrypt small pieces of information.

Asymmetric-key

Locking and unlocking in asymmetric-key cryptosystem



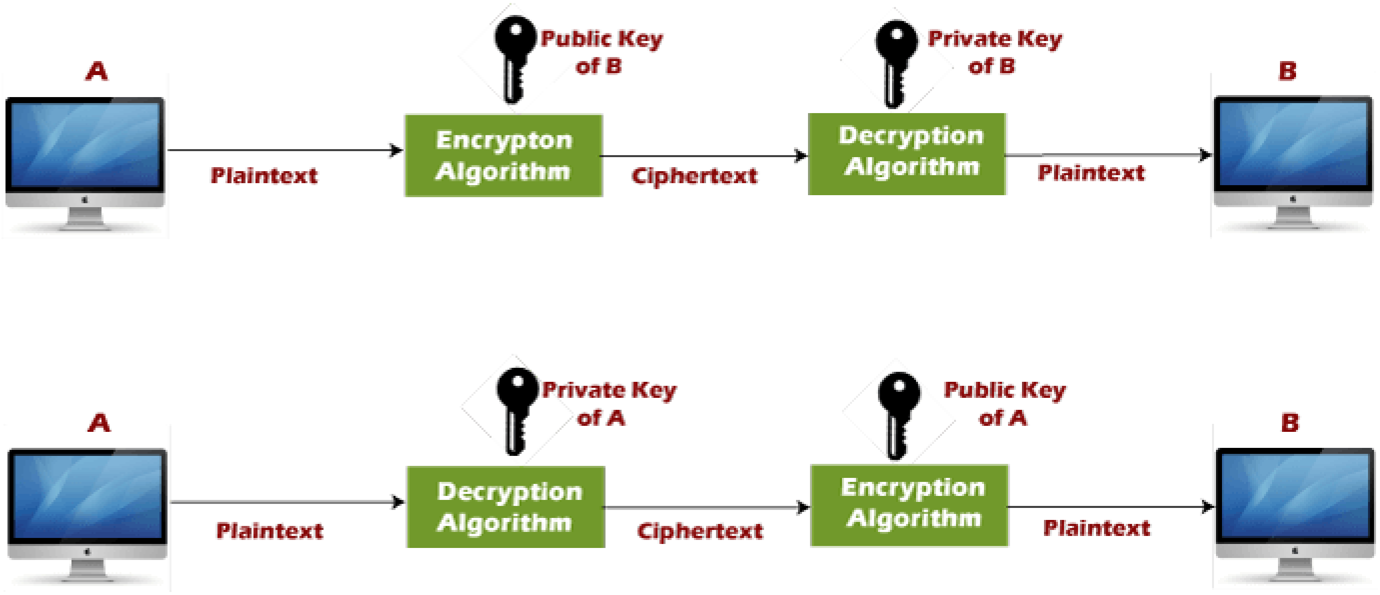
Asymmetric-key ciphers are sometimes called public-key ciphers.

Asymmetric-key cryptography is normally used to encrypt or decrypt small pieces of information.

Asymmetric-key

RSA algorithm is an asymmetric cryptography algorithm. Asymmetric actually means that it works on two different keys i.e. **Public Key** and **Private Key.** As the name describes that the Public Key is given to everyone and the Private key is kept private.

The Public key algorithm operates in the following manner:

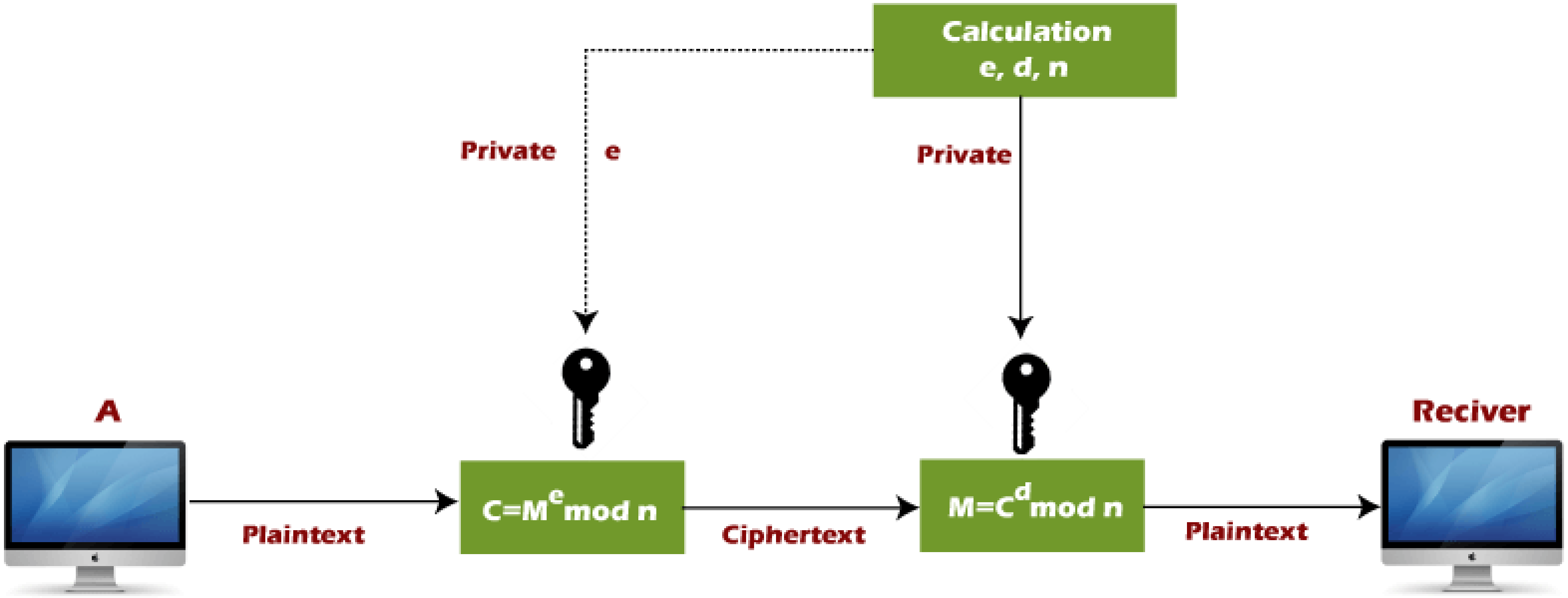


Encryption/decryption using public/private keys

Asymmetric-key

RSA encryption algorithm:

RSA is the most common public-key algorithm, named after its inventors **Rivest, Shamir, and Adelman (RSA).**



RSA

Application Layer Protocols

RSA algorithm uses the following procedure to generate public and private keys:

- Select two large prime numbers, p and **q**.
- Multiply these numbers to find **n = p x q,** where **n** is called the modulus for encryption and decryption.
- Choose a number **e** less than **n**, such that n is relatively prime to **(p - 1) x (q -1).** It means that **e** and **(p - 1) x (q - 1)** have no common factor except 1. Choose "e" such that 1<e < ф (n), e is prime to ф (n), **gcd (e,d(n)) =1**
- If **n = p x q,** then the public key is <e, n>. A plaintext message **m** is encrypted using public key <e, n>. To find ciphertext from the plain text following formula is used to get ciphertext C.

RSA

C.

C = m^e mod n

Here**, m** must be less than **n**. A larger message (>n) is treated as a concatenation of messages, each of which is encrypted separately.

•To determine the private key, we use the following formula to calculate the d such that:

D_e mod {(p - 1) x (q - 1)} = 1

Or

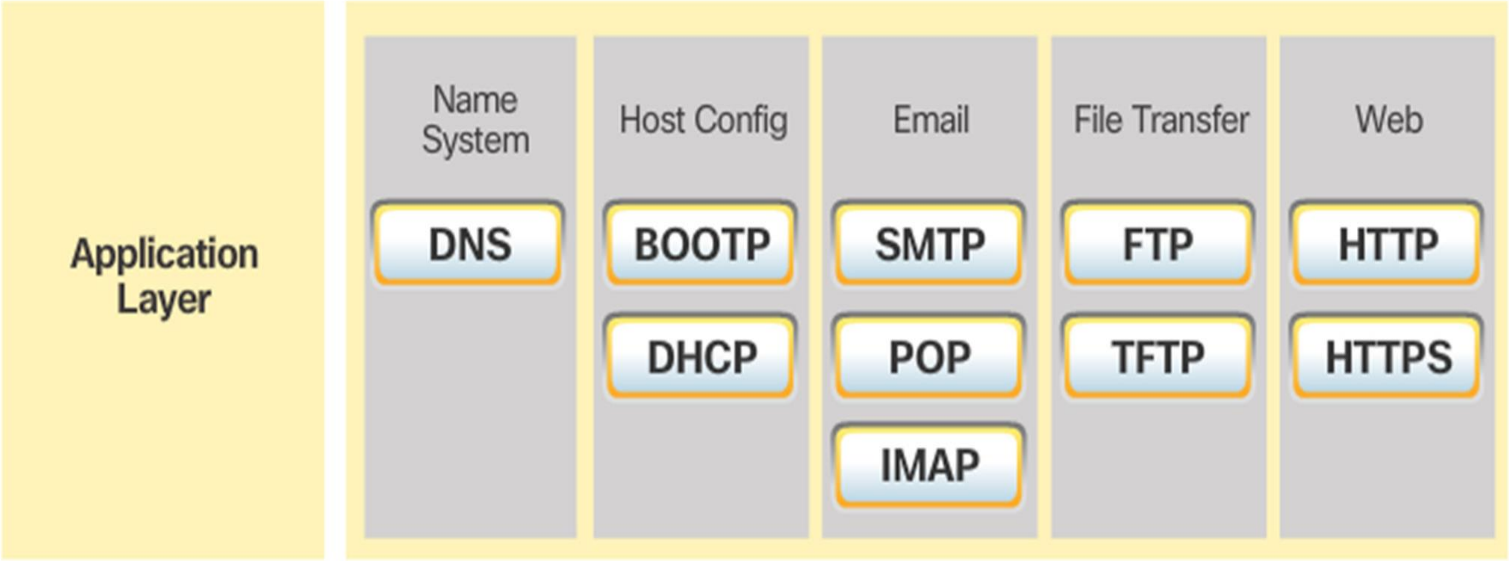
D_e mod ϕ (n) = 1

•The private key is <d, n>. A ciphertext message **c** is decrypted using private key <d, n>. To calculate plain text **m** from the ciphertext c following formula is used to get plain text m.

m = c^d mod n

Application Layer Protocols

- TCP/IP application protocols specify the format and control information necessary for common Internet functions.
- Application layer protocols must be implemented in both the source and destination devices.
- Application layer protocols implemented on the source and destination host must be compatible to allow communication.



Application Layer

Name System	Host Config	Email	File Transfer	Web
DNS	BOOTP	SMTP	FTP	HTTP
	DHCP	POP	TFTP	HTTPS
		IMAP		

Application Layer services

1.Network Virtual terminal:

An application layer allows a user to log on to a remote host. The user's computer talks to the software terminal, which in turn, talks to the host. The remote host thinks that it is communicating with one of its own terminals, so it allows the user to log on.

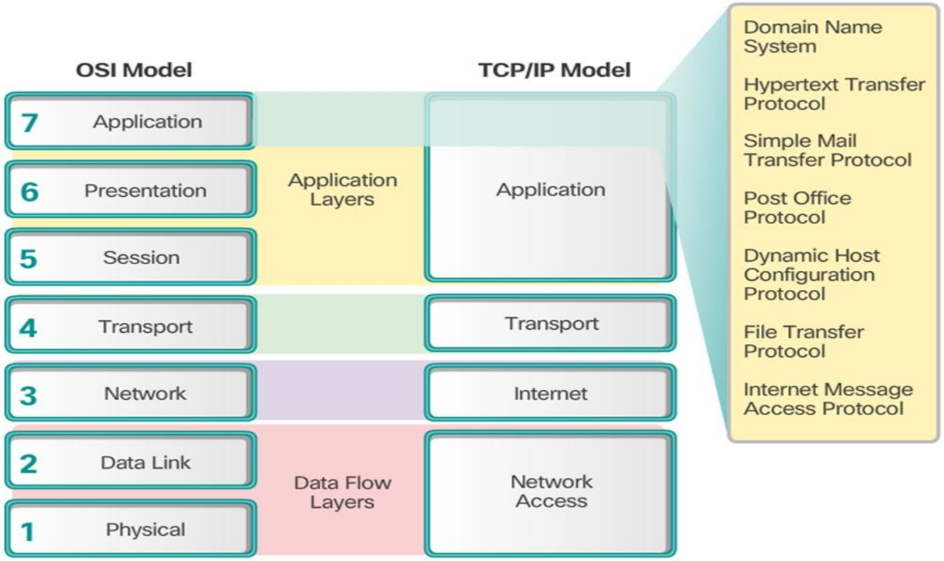
2.File Transfer, Access, and Management :

An application allows a user to access files in a remote computer, to retrieve files from a computer and to manage files in a remote computer.

Application Layer

Objective: Study about basic concept Application layer and its function

- The application layer is closest to the end user.
- Network applications enable users to send and receive data with ease.
- The application layer acts as interface between the applications and the underlying network.
- Application layer protocols help exchange data between programs running on the source and destination hosts.
- The TCP/IP application layer performs the functions of the upper three layers of the OSI model.
- Common application layer protocols include: HTTP, FTP, TFTP, DNS.



Application Layer services

3.Addressing:

To obtain communication between client and server, there is a need for addressing. When a client made a request to the server, the request contains the server address and its own address. The server response to the client request, the request contains the destination address, i.e., client address. To achieve this kind of addressing, DNS is used.

4.Mail Services:

An application layer provides Email forwarding and storage 5.Directory Services: An application contains a distributed database that provides access for global information about various objects and service.

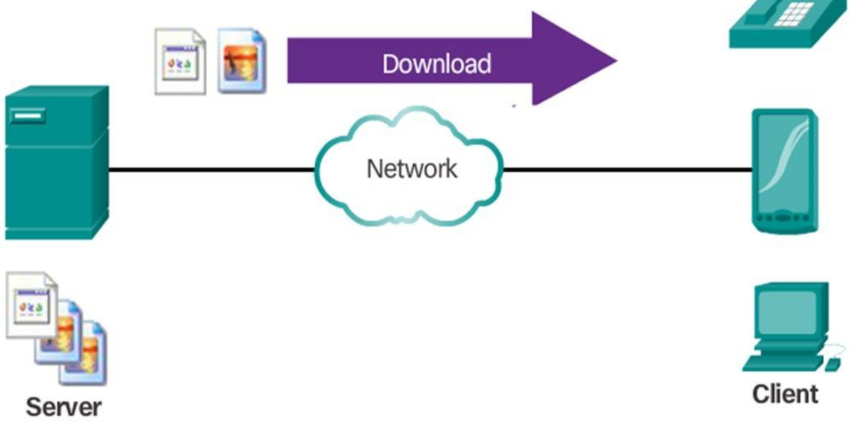
Client Server Model

Objective: Study about basic concept of Client Server & Peer to Peer model and it uses

- The device requesting the information is called a client.
- The device responding to the request is called a server.
- Client and server processes are considered to be in the application layer.
- The client initiates the exchange by requ
- The server responds by sending one or r streams of data to the client.
- Application layer protocols describe the of the requests and responses between and servers.
- The contents of the data exchange will c of the application in use.
- Email is an example of a Client-Server interaction.

Client/Server Model

Files are downloaded from the server to the client.



Resources are stored on the server.

A client is a hardware/software combination that people use directly.

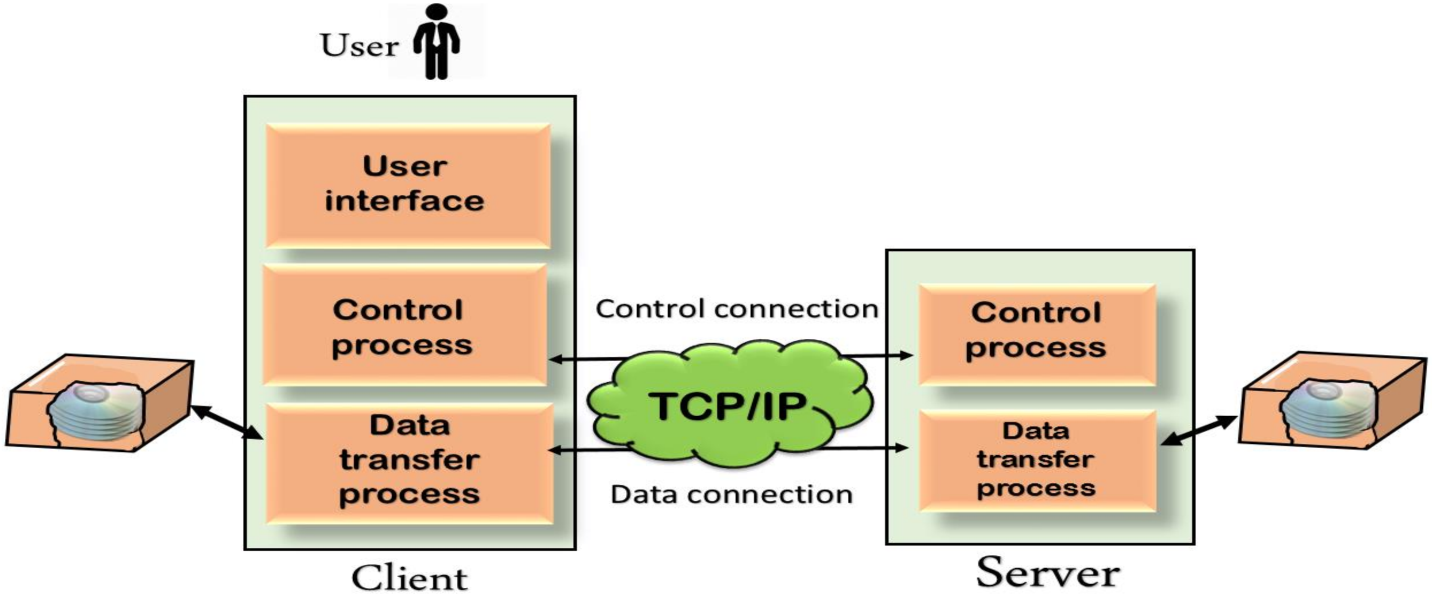
FTP (File transfer Protocol)(CO5)

- FTP is a standard internet protocol provided by TCP/IP used for transmitting the files from one host to another. It is mainly used for transferring the web page files from their creator to the computer that acts as a server for other computers on the internet. It is also used for downloading the files to computer from other servers.
- **Why FTP?**

  Although transferring files from one system to another is very simple and straightforward, but sometimes it can cause problems. For example, two systems may have different file conventions. Two systems may have different ways to represent text and data. Two systems may have different directory structures. FTP protocol overcomes these problems by establishing two connections between hosts. One connection is used for data transfer, and another connection is used for the control connection.

FTP (File transfer Protocol)(CO5)

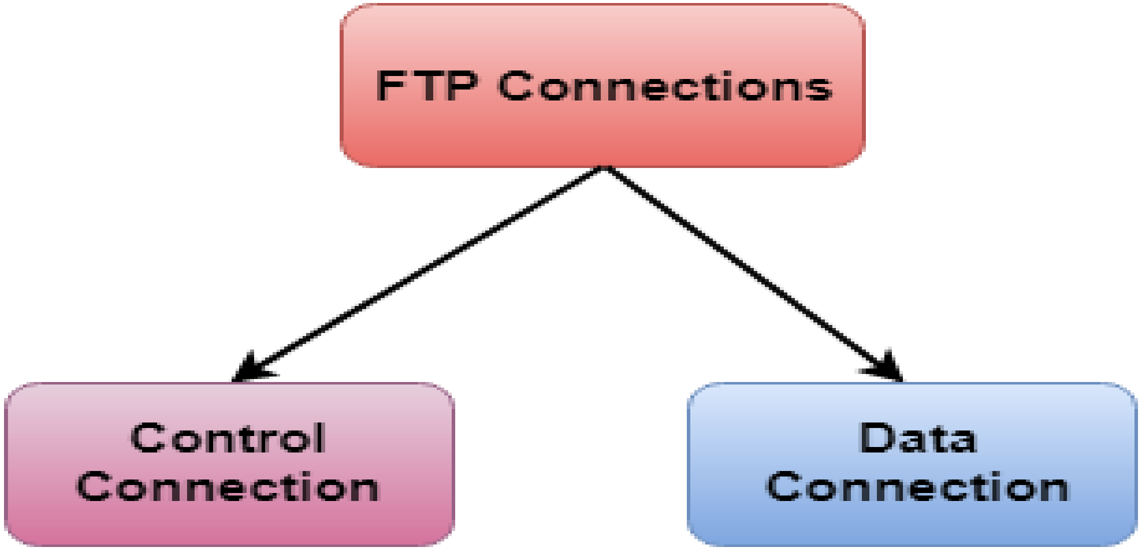
- **Mechanism of FTP**



The above figure shows the basic model of the FTP. The FTP client has three components: the user interface, control process, and data transfer process. The server has two components: the server control process and the server data transfer process

FTP (File transfer Protocol)(CO5)

- **There are two types of connections in FTP**



FTP (File transfer Protocol)(CO5)

- **Control Connection:** The control connection uses very simple rules for communication. Through control connection, we can transfer a line of command or line of response at a time. The control connection is made between the control processes. The control connection remains connected during the entire interactive FTP session.
- **Data Connection:** The Data Connection uses very complex rules as data types may vary. The data connection is made between data transfer processes. The data connection opens when a command comes for transferring the files and closes when the file is transferred.

FTP (File transfer Protocol)(CO5)

FTP Clients

- FTP client is a program that implements a file transfer protocol which allows you to transfer files between two hosts on the internet.
- It allows a user to connect to a remote host and upload or download the files.
- It has a set of commands that we can use to connect to a host, transfer the files between you and your host and close the connection.
- The FTP program is also available as a built-in component in a Web browser. This GUI based FTP client makes the file transfer very easy and also does not require to remember the FTP commands

FTP (File transfer Protocol)(CO5)

Objectives of FTP

- It provides the sharing of files.
- It is used to encourage the use of remote computers.
- It transfers the data more reliably and efficiently

Advantages of FTP:

- **Speed:** One of the biggest advantages of FTP is speed. The FTP is one of the fastest way to transfer the files from one computer to another computer.
- **Efficient:** It is more efficient as we do not need to complete all the operations to get the entire file.

Security: To access the FTP server, we need to login with the username and password. Therefore, we can say that FTP is more secure

FTP (File transfer Protocol)(CO5)

Disadvantages of FTP:

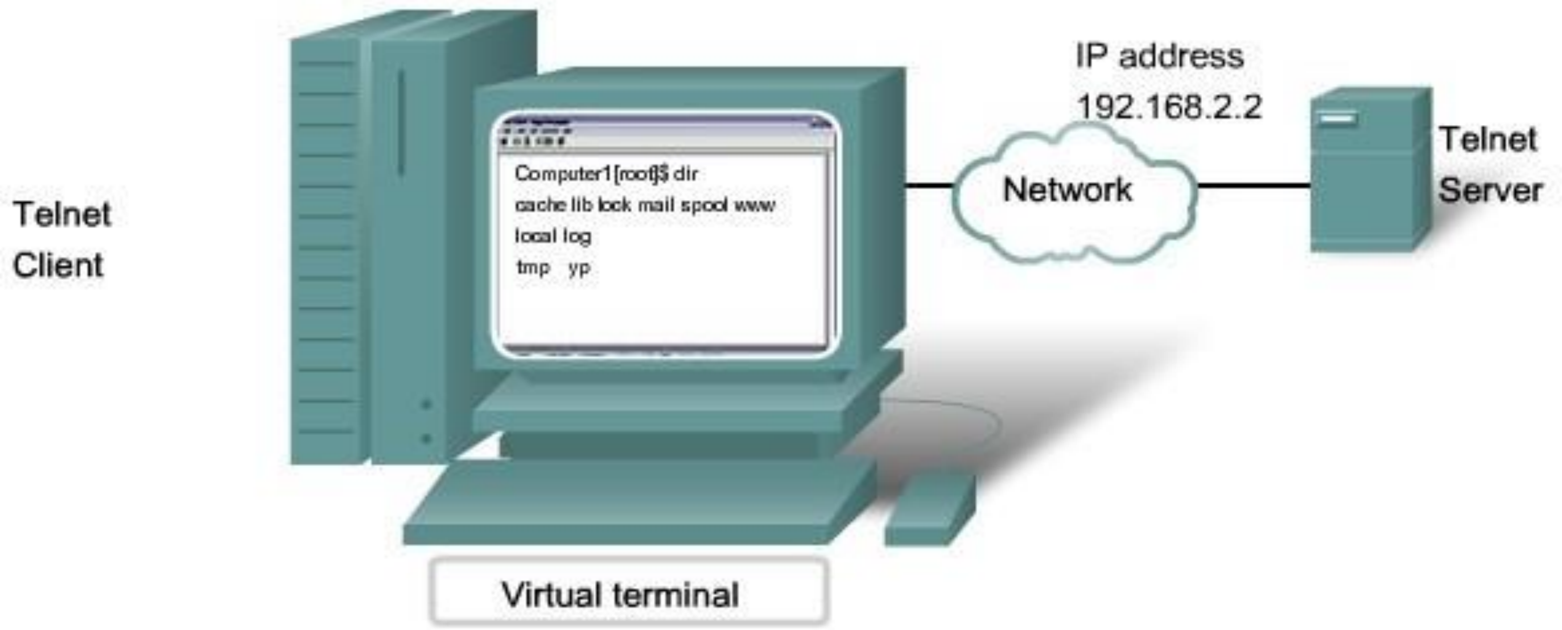
- The standard requirement of the industry is that all the FTP transmissions should be encrypted. However, not all the FTP providers are equal and not all the providers offer encryption. So, we will have to look out for the FTP providers that provide encryption.
- FTP serves two operations, i.e., to send and receive large files on a network. However, the size limit of the file is 2GB that can be sent. It also doesn't allow you to run simultaneous transfers to multiple receivers.
- Passwords and file contents are sent in clear text that allows unwanted eavesdropping. So, it is quite possible that attackers can carry out the brute force attack by trying to guess the FTP password.
- It is not compatible with every system

Telnet

- Developed in the early 1970’s – among the oldest of the application layer protocols and services in the TCP/IP protocol suite.
- Allows users to follow text-based terminal devices over the network using software.
- A connection is known as a ‘virtual terminal (vty)’ session.
- Can be run from the command prompt on a PC.
- You can use the device as if you were sitting there with all the rights and priorities that you username will offer you.
- TELNET requires a login name and password, it is vulnerable to hacking because it sends all data including the password in plaintext (not encrypted). A hacker can eavesdrop and obtain the logging name and password. Because of this security issue, the use of TELNET has diminished in favor of another protocol, Secure Shell (SSH).

Telnet

Telnet



```
Computer1[root]$ dir
cache lib lock mail spool www
local log
tmp   yp
```

Telnet provides a way to use a computer, connected via the network, to access a network device as if the keyboard and monitor were directly connected to the device.

Daily Quiz

1. Transport layer aggregates data from different applications into a single stream before passing it to ____________
a) network layer
b) data link layer
c) application layer
d) physical layer

2. Which of the following are transport layer protocols used in networking?
a) TCP and FTP
b) UDP and HTTP
c) TCP and UDP
d) HTTP and FTP

3. User datagram protocol is called connectionless because _____________
a) all UDP packets are treated independently by transport layer
b) it sends data as a stream of related packets
c) it is received in the same order as sent order
d) it sends data very quickly

Daily Quiz

4. Transmission control protocol ___________
a) is a connection-oriented protocol
b) uses a three way handshake to establish a connection
c) receives data from application as a single stream
d**)** all of the mentioned

5. Transport layer protocols deals with ____________
a) application to application communication
b**)** process to process communication
c) node to node communication
d) man to man communication

6. Transport layer aggregates data from different applications into a single stream before passing it to:
A. network layer
B. data link layer
C. application layer
D. physical layer

Weekly Assignment

1. Explain the main idea of UDP.

2. Define TCP.

3. Advantage and disadvantage of FTP.

4. Define FTP protocols.

Recap

- The Data Connection uses very complex rules as data types may vary.

Topic Links

- https://www.youtube.com/watch?v=VdHFk39GEZ0

Daily Quiz

- Which is not a application layer protocol?
  a) HTTP
  b) SMTP
  c) FTP
  d**)** TCP
- The packet of information at the application layer is called ___________
  a) Packet
  b**)** Message
  c) Segment
  d) Frame
- E-mail is __________
  a) Loss-tolerant application
  b) Bandwidth-sensitive application
  c**)** Elastic application
  d) None of the mentioned

Daily Quiz

- Application layer offers _______ service.
  a**)** End to end
  b) Process to process
  c) Both End to end and Process to process
  d) None of the mentioned
- Which of the following is an application layer service?
  a) Network virtual terminal
  b) File transfer, access, and management
  c) Mail service
  d**)** All of the mentioned
- Electronic mail uses which Application layer protocol?
  a**)** SMTP
  b) HTTP
  c) FTP
  d) SIP

Weekly Assignment

1. Discuss the TCP connections needed in FTP.

2. Write short note on IP Data Gram.

3. What is the difference between a user agent (UA) and a mail transfer agent? (MTA)?

4. Why is an application such as POP needed for electronic messaging?

5. What do you understand by ATM? Explain cell header format in ATM and briefly describe the four services classes of ATM.

Recap

- We learn about Application Layer and protocol working on this layer .
- In this we learn about File transfer protocol.

Topic Links

https://www.youtube.com/watch?v=nP-p4R5Y55I

https://www.youtube.com/watch?v=6jKGSthvIjY

TRADITIONAL CIPHERS

Ciphers: secret writing

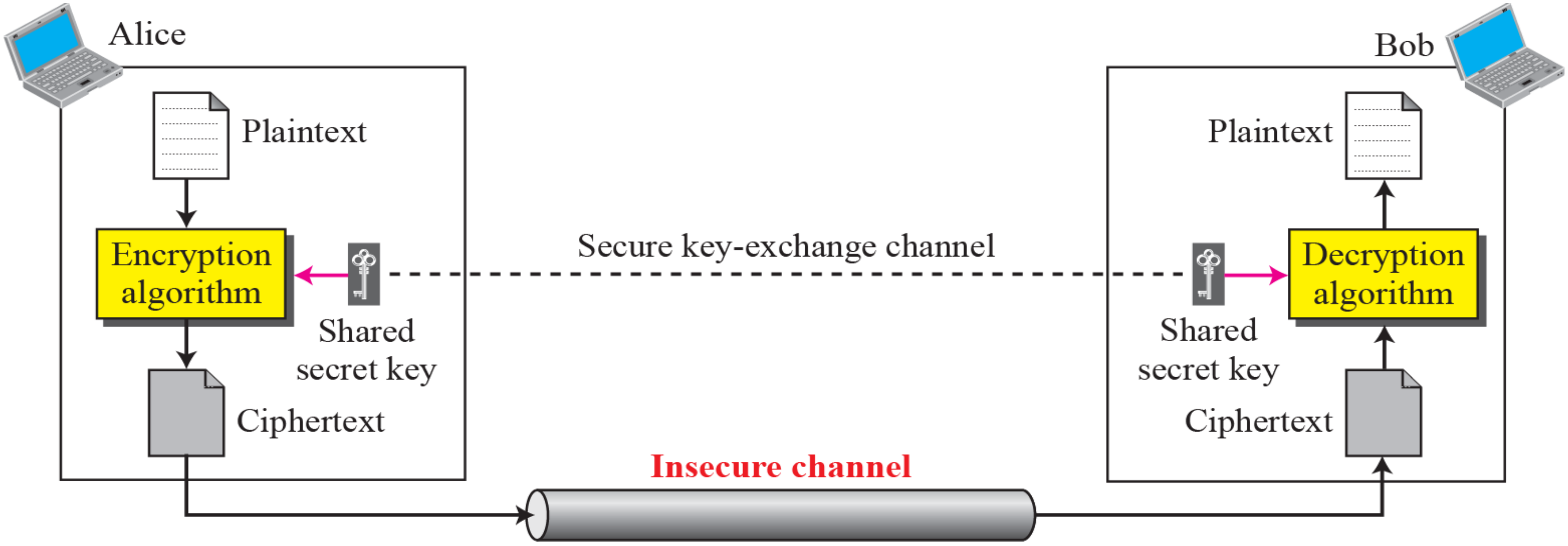
Cryptography : process of secret writing

first goal of security is confidentiality
Confidentiality can be achieved using ciphers.

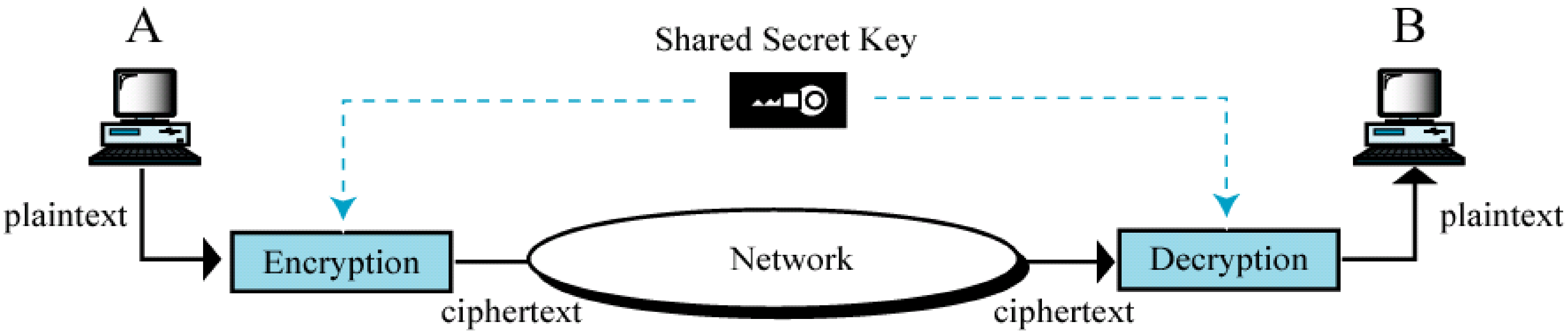
Encryption: converting original msg to cipher msg so that can not be understand by any other. (at the sender side)

Decryption : converting cipher msg to original msg (at the receiver side)

General idea of traditional cipher

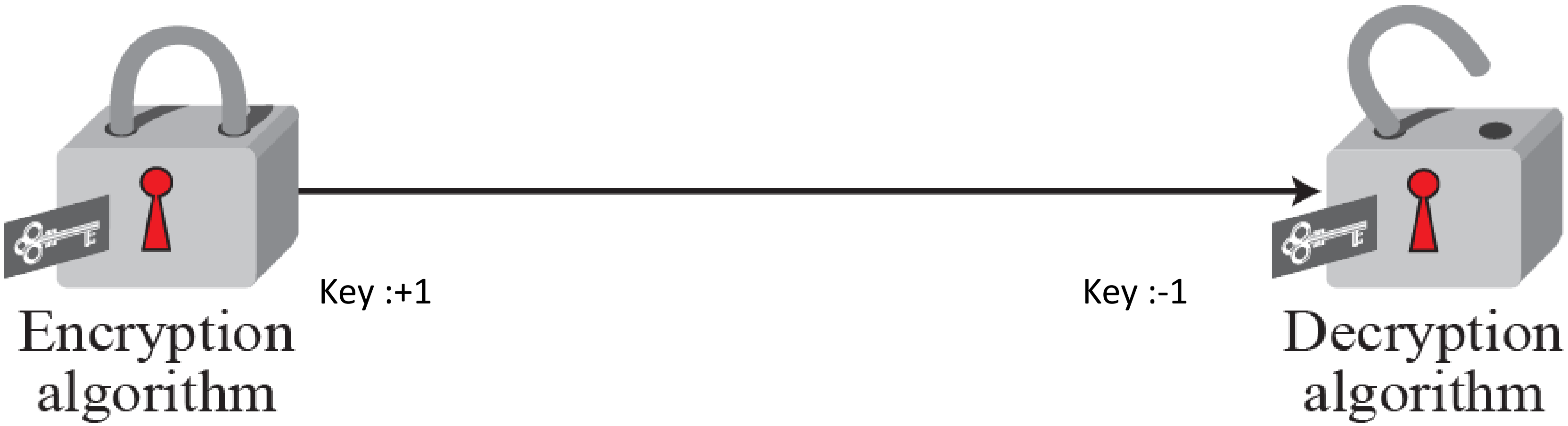


Secret key encryption/ symmetric Key



Symmetric-key: substitution Method

locking and unlocking with the same key



Key :+1

Key :-1

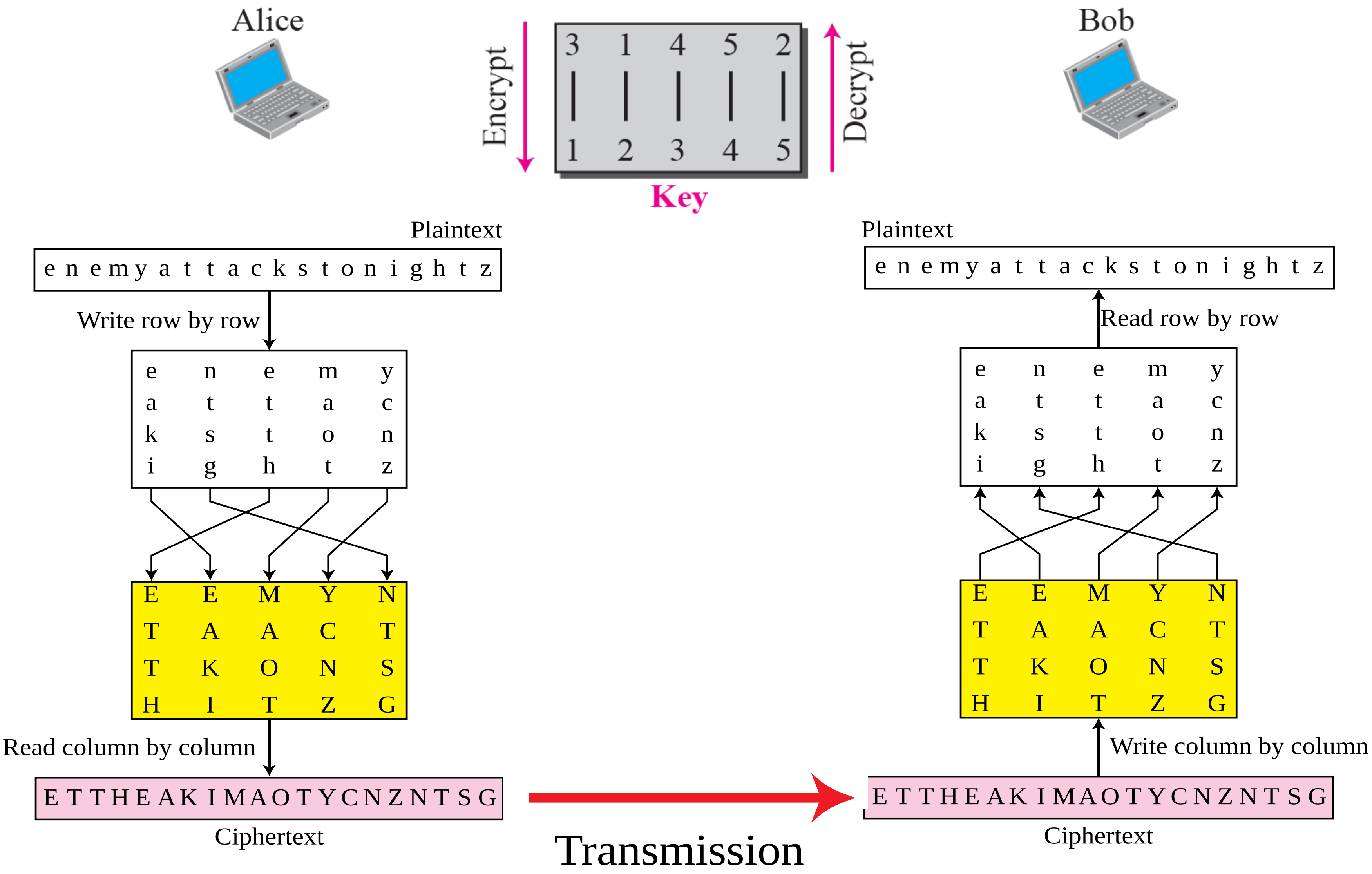
A substitution cipher replaces one symbol

Original msg: HELLO

Cypher msg: IFMMP

Key : 1

Symmetric-key: Transposition cipher



3	1	4	5	2
1	2	3	4	5

e n e m y a t t a c k s t o n i g h t z

e	n	e	m	y
a	t	t	a	c
k	s	t	o	n
i	g	h	t	z

E	E	M	Y	N
T	A	A	C	T
T	K	O	N	S
H	I	T	Z	G

E T T H E A K I M A O T Y C N Z N T S G

Cryptography(CO5)

- Computer data often travels from one computer to another, leaving the safety of its protected physical surroundings. Once the data is out of hand, people with bad intention could modify or forge your data, either for amusement or for their own benefit.
- Cryptography can reformat and transform our data, making it safer on its trip between computers. The technology is based on the essentials of secret codes, augmented by modern mathematics that protects our data in powerful ways.

Cryptographic systems are generally classified along 3 independent dimensions:

- Type of operations used for transforming plain text to cipher text
- The number of keys used
- Cryptanalysis:

Cryptography(CO5)

- **Type of operations used for transforming plain text to cipher text:** All the encryption algorithms are based on two general principles: substitution, in which each element in the plaintext is mapped into another element, and transposition, in which elements in the plaintext are rearranged.
- **The number of keys used:** If the sender and receiver uses same key then it is said to be symmetric key (or) single key (or) conventional encryption. If the sender and receiver use different keys then it is said to be public key encryption. The way in which the plain text is processed

Cryptography(CO5)

Cryptanalysis:

- The process of attempting to discover X or K or both is known as cryptanalysis. The strategy used by the cryptanalysis depends on the nature of the encryption scheme and the information available to the cryptanalyst. There are various types of cryptanalytic attacks based on the amount of information known to the cryptanalyst.

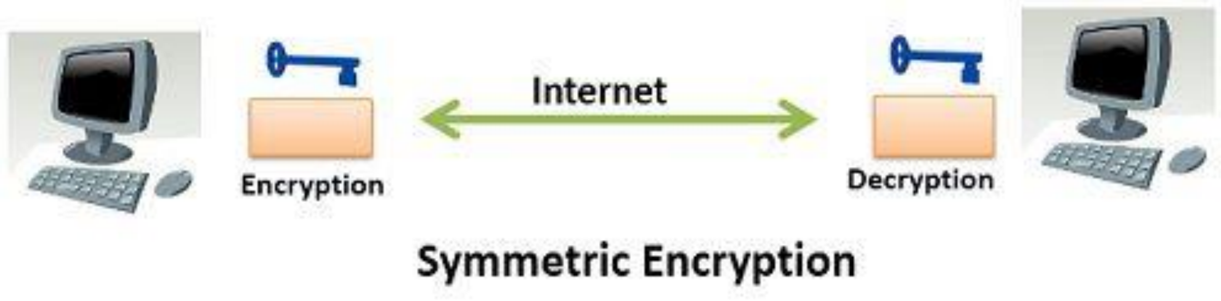
Cryptographic Attacks

- Passive Attacks
- Active attacks

Cryptography(CO5)

- **Symmetric Cryptography**

  Symmetric encryption is a technique which allows the use of only one key for performing both the encryption and the decryption of the message shared over the internet. It is also known as the conventional method used for encryption.



Cryptography(CO5)

- **DES (Data Encryption Standard)**

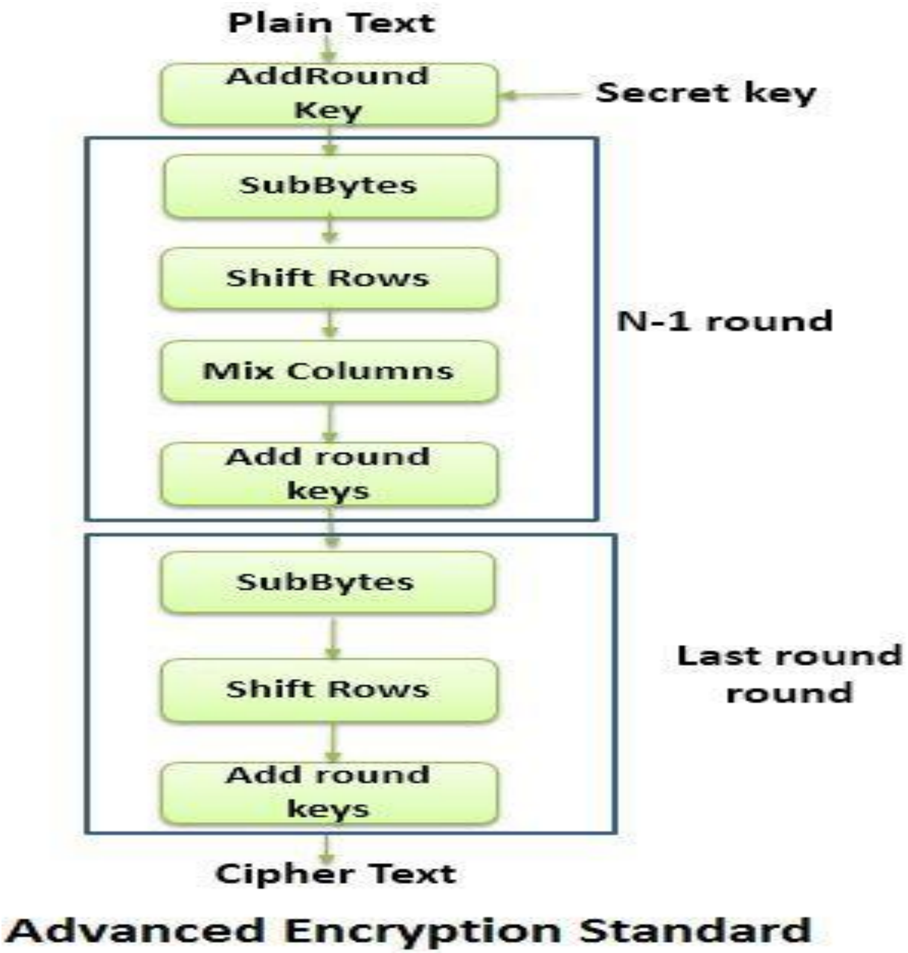
  Data Encryption Standard (DES) is a symmetric key block cipher that was adopted by National Institute of Standard and Technology in the year 1977. DES is based on the Feistel structure where the plaintext is divided into two halves. DES takes input as 64-bit plain text and 56-bit key to produce 64-bit Ciphertext.

Cryptography(CO5)

AES (Advanced Encryption Standard):

- Advanced Encryption Standard (AES) is also a symmetric key block cipher. AES was published in 2001 by the National Institute of Standards and Technology. AES was introduced to replace DES as DES uses very small cipher key and the algorithm was quite slower.
- AES algorithm takes 128-bit plaintext and 128-bit secret key which together forms a 128-bit block which is depicted as 4 X 4 square matrix. This 4 X 4 square matrix undergoes an initial transformation.

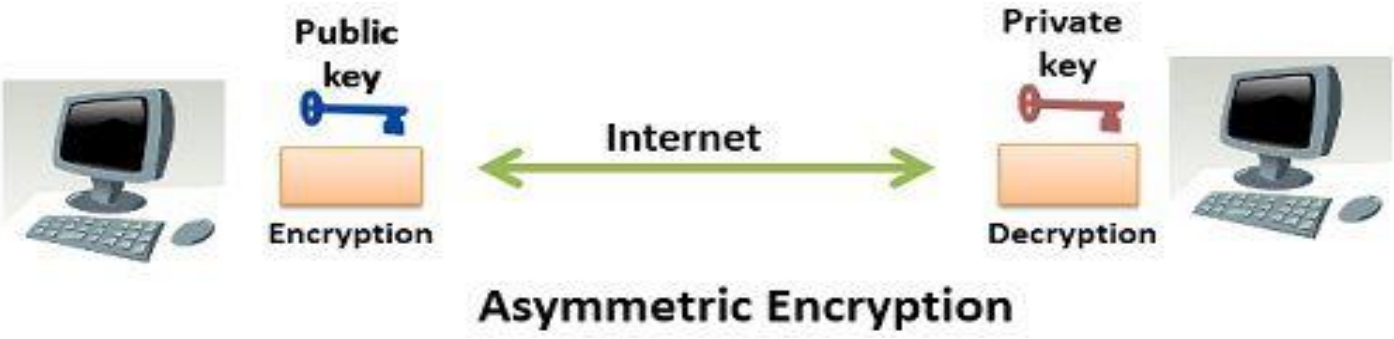
Cryptography(CO5)



Cryptography(CO5)

- **Asymmetric Cryptography:**

  Asymmetric encryption is an encryption technique that uses a pair of key (private key and public key) for encryption and decryption. Asymmetric encryption uses the public key for the encryption of the message and the private key for the decryption of the message. The public key is freely available to anyone who is interested in sending the message.



Daily Quiz

- Transport services available to applications in one or another form __________
  a) Reliable data transfer
  b) Timing
  c) Security
  d) All of the mentioned

- We use cryptography term to transforming message to make them:

a) Secure and immune to change
b) Secure and immune to idle
c) Secure and immune to attacks
d) Secure and immune to defend

- The number of objects in a Web page which consists of 4 jpeg images and HTML text is _________
  a) 4
  b) 1
  c) 5
  d) 7

Daily Quiz

- The time taken by a packet to travel from client to server and then back to the client is called __________
  a) STT
  b) RTT
  c) PTT
  d) JTT

- The first line of HTTP request message is called _____________
  a) Request line
  b) Header line
  c) Status line
  d) Entity line

Weekly Assignment

1. What is Cryptography? Differentiate between symmetric key cryptography and asymmetric key cryptography
2. What is plaintext or clear text?
3. How does the encryption process actually take place?
4. What are the origins of cryptography?
5. What is the goal of cryptography?

Topic Links

- https://www.youtube.com/watch?v=y4KoiJmr8gE
- https://www.youtube.com/watch?v=pnoWCK82apU

Network Security(CO5)

- **What is Network Security?**

  Network security is the process of taking preventative measures to protect the underlying networking infrastructure from unauthorized access, misuse, malfunction, modification, destruction or improper disclosure. The Internet has undoubtedly become a huge part of our lives. Many people in today’s generation rely on the Internet for many of their professional, social and personal activities.

  There are many people who attempt to damage our Internet-connected computers, violate our privacy and make it impossible to the Internet services. Given the frequency and variety of existing attacks as well as the threat of new and more destructive future attacks, network security has become a central topic in the field of cyber security.

Network Security(CO5)

- **What is network security attack?**

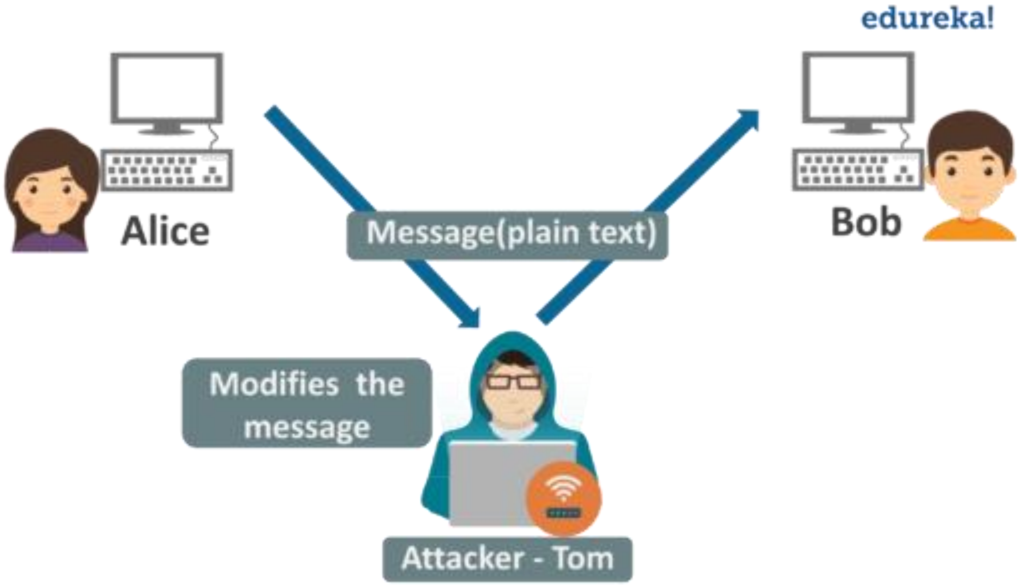
  A *network attack* can be defined as any method, process, or means used to maliciously attempt to compromise network security. Network security is the process of preventing network attacks across a given network infrastructure, but the techniques and methods used by the attacker further distinguish whether the attack is an active cyber attack, a passive type attack, or some combination of the two.

- Let’s consider a simple network attack example to understand the difference between active and passive attack

Network Security(CO5)

- **Active Attacks**

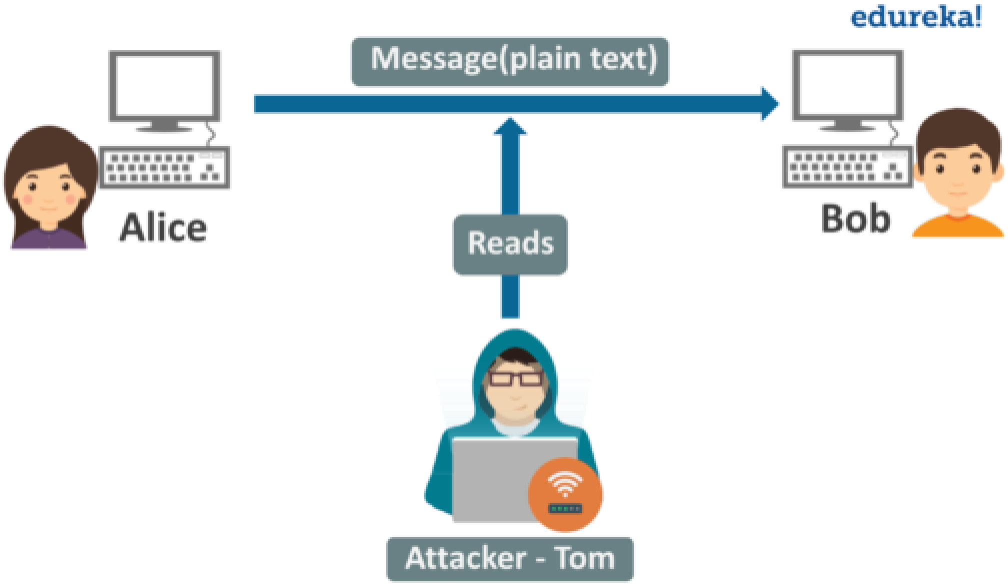
  An active attack is a network exploit in which attacker attempts to make changes to data on the target or data en route to the target**.**



Network Security(CO5)

- **Passive Attacks**

  A passive attack is a network attack in which a system is monitored and sometimes scanned for open ports and vulnerabilities, but does not affect system resources.



Daily Quiz

- The ______________ translates internet domain and host names to IP address.
  a) domain name system
  b) routing information protocol
  c) network time protocol
  d) internet relay chat
- Which one of the following allows a user at one site to establish a connection to another site and then pass keystrokes from local host to remote host?
  a) HTTP
  b) FTP
  c) Telnet
  d) TCP
- Application layer protocol defines _____________
  a) types of messages exchanged
  b) message format, syntax and semantics
  c) rules for when and how processes send and respond to messages
  d) all of the mentioned

Weekly Assignment

1. What is Cryptography? Differentiate between symmetric key cryptography and asymmetric key cryptography
2. What is plaintext or clear text?
3. How does the encryption process actually take place?
4. What are the origins of cryptography?
5. What is the goal of cryptography?

Recap

- Cryptography and Network security.
- Learn about congestion control in Networking system .

Topic Links

- https://www.youtube.com/watch?v=y4KoiJmr8gE
- https://www.youtube.com/watch?v=pnoWCK82apU

Faculty Video Links, Youtube & NPTEL Video Links and Online Courses Details

- https://www.youtube.com/watch?v=lCy_KUfhBbw
- https://www.youtube.com/watch?v=fTPbiedSGMw
- https://www.youtube.com/watch?v=y4KoiJmr8gE
- https://www.youtube.com/watch?v=pnoWCK82apU
- https://www.youtube.com/watch?v=VdHFk39GEZ0

Weekly Assignment 1

- Explain Application layer protocols .
- Write short on Network security and how we secure network ?
- Write short note on Cryptography.
- What is Electronic Mail and what is the part of a E-mail.
- Briefly Explain the issue involved in using ATM technology in LAN's.
- Explain concept of traffic shaping ?

Weekly Assignment 2

1. What is Cryptography? Differentiate between symmetric key cryptography and asymmetric key cryptography
2. What is plaintext or clear text?
3. How does the encryption process actually take place?
4. What are the origins of cryptography?
5. What is the goal of cryptography?

MCQs

1.Who translates internet domain and host names to IP address.

a) domain name system

b) routing information protocol

c) network time protocol

d) internet relay chat

Answer: a

2. Which allows a user at one site to establish a connection to another site?

a) HTTP

b) FTP

c) Telnet

d) TCP

Answer: c

MCQs

3. which wil define Application layer protocol

a) types of messages exchanged

b) message format, syntax and semantics

c) rules processes send and respond to messages

d) all of the mentioned

Answer: d

4. Which one protocol delivers/stores mail to reciever server?

a) simple mail transfer

b) post office

c) internet mail access

d) hypertext transfer

Answer: a

MCQs

5. ASCII_____________ encoding of binary data

a) base 64 encoding

b) base 32 encoding

c) base 16 encoding

d) base 8 encoding

Answer: a

6. __________is an internet standard protocol.

a) dynamic host configuration

b) simple network management

c) internet message access

d) media gateway

Answer: b

MCQs

7.Which DNS client maps an address to a name especially when required a host?
a) Resolver
b) Mapper
c) Primary Server
d) Secondary Server
Answer: a

8.which one option from following Application-level protocol plays a crucial role in addition to X-500 features
a) TCP
b) LDAP
c) FTP
d) None of the above
Answer : b

MCQs

9. Which of the following intermediarie get involved during the transfer function of an e-mail system?

a) Storage and forwarding of e-mail for certain addresses
b) Act as gateways to other e-mail
c) Both a & b
d) None of the above

Answer:c

10.________ among the below specified illustrations the category of GUI

a) mail
b) pine
c) Outlook & Netscape
d) All of the above

Answer:c

MCQs

11. ____________URL method of HTTP performs similar function as that of PUT an exception of request .

a) POST
b) GET
c) PATCH
d) OPTION

Answer:c

12.______________language in WWW specifies a web's way by three-dimensional objects?

a) HTML
b) VRML
c) XML
d) UML

Answer:b

MCQs

13.which field of cookie in WWW represents the server's directory structure

a) Domain
b) Path
c) Content
d) Secure

Answer:b

14. Which of the following among the below mentioned protocols provides a mechanism of acquiring an IP address?

a) BOOTP
b) DHCP
c) Both a & b
d) None of the above

Answer:b

MCQs

15. Which is the important applications of application layer?

a) Electronic mail
b) World Wide Web
c) USENET
d) All of the above

Answer:d

16. The TCP/IP corresponds to the combined session, presentation, and application layers of the OSI model.

a) session
b) presentation
c) application
d) None of the above

Answer:c

MCQs

17.which protocol is based on end-to-end delivery.

a) SMTP
b) TCP
c) IP
d) SCTP

Answer:a

18. The well-known port of SMTP server is__________.

a) 110
b) 25
c) 50
d) 20

Answer:b

MCQs

19__________is a summary of the message being sent which specified by the sender.

a) Reply-to
b) Return-path
c) Subject
d) From

Answer:c

20. In SMTP herder field is added by the final transport system.

a) Reply-to
b) Return-path
c) Subject
d) From

Answer:b

Glossary Questions

Choose most appropriate

(TCP and UDP, Ten, Network layer, five, Process to process communication)

- Transport layer protocols deals with _____________
- _____________ transport layer protocols used in networking.
- Transport layer aggregates data from different applications into a single stream before passing it to _____________
- The number of objects in a Web page which consists of 4 jpeg images and HTML text is _________
- _________ protocols used in application layer.

Old Question Papers

- https://firstranker.com/fr.php/frdA290120A17171122/download-aktu-b-tech-6th-sem-2018-2019-KCS603-computer-network-question-paper
- ACSE0602 CN.docx (sharepoint.com)

Expected Questions for University Exam

- What is FTP protocol and how different from SMTP protocol.
- What is Email?
- Write short notes on

  a)Cryptography

  b)Network security
- What is Congestion control .
- Discuss Application layer and importance of in OSI model.

References

- 1. Computer Networking- A Top-Down approach, 5th edition, Kurose and Ross, Pearson
- 2. Computer Networks- A Top-Down approach, Behrouz Forouzan, McGraw Hill
- 3. Computer Networks (4th edition), Andrew Tanenbaum, Prentice Hall
- 4. Computer Networking and the Internet (5th edition),Fred Halsall, Addison Wesley

Recap of Unit

- We learn about Application Layer and protocol working on this layer .
- In this we learn about File transfer protocol.
- Email and how it used
- Cryptography and Network security.
- Learn about congestion control in Networking system .

THANK YOU

WISH YOU ALL THE VERY BEST