Application Layer - Part III & Doubt Clearing Session

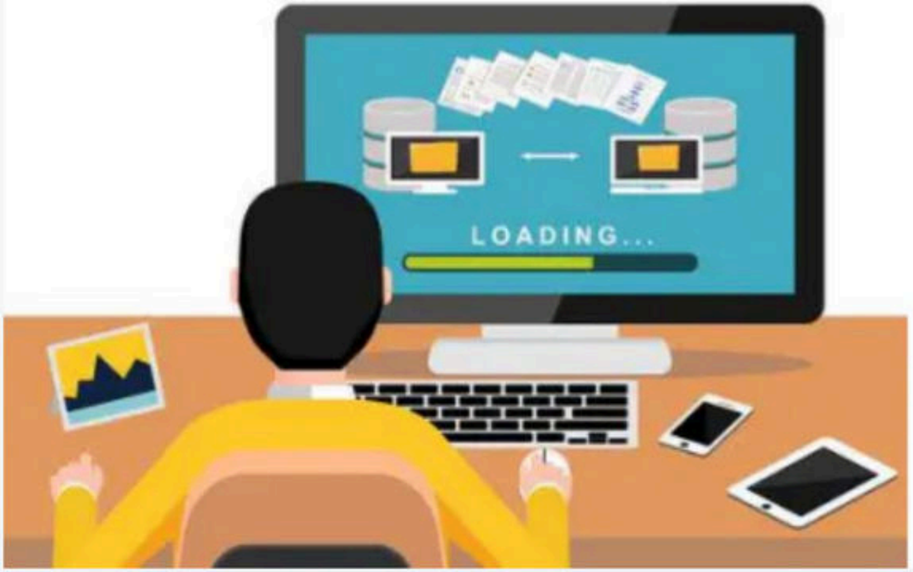
Complete Course on Computer Networks - Part IV

Ravindrababu Ravula • Lesson 7 • May 11, 2021

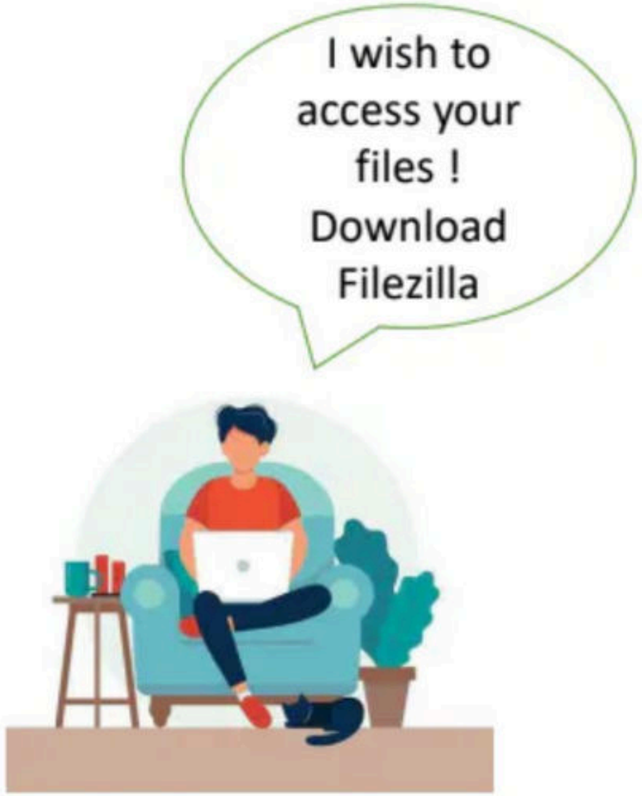
My philosophy
TEACHING IS WORSHIP
STUDENTS ARE GODS
Thank you
for
trusting me

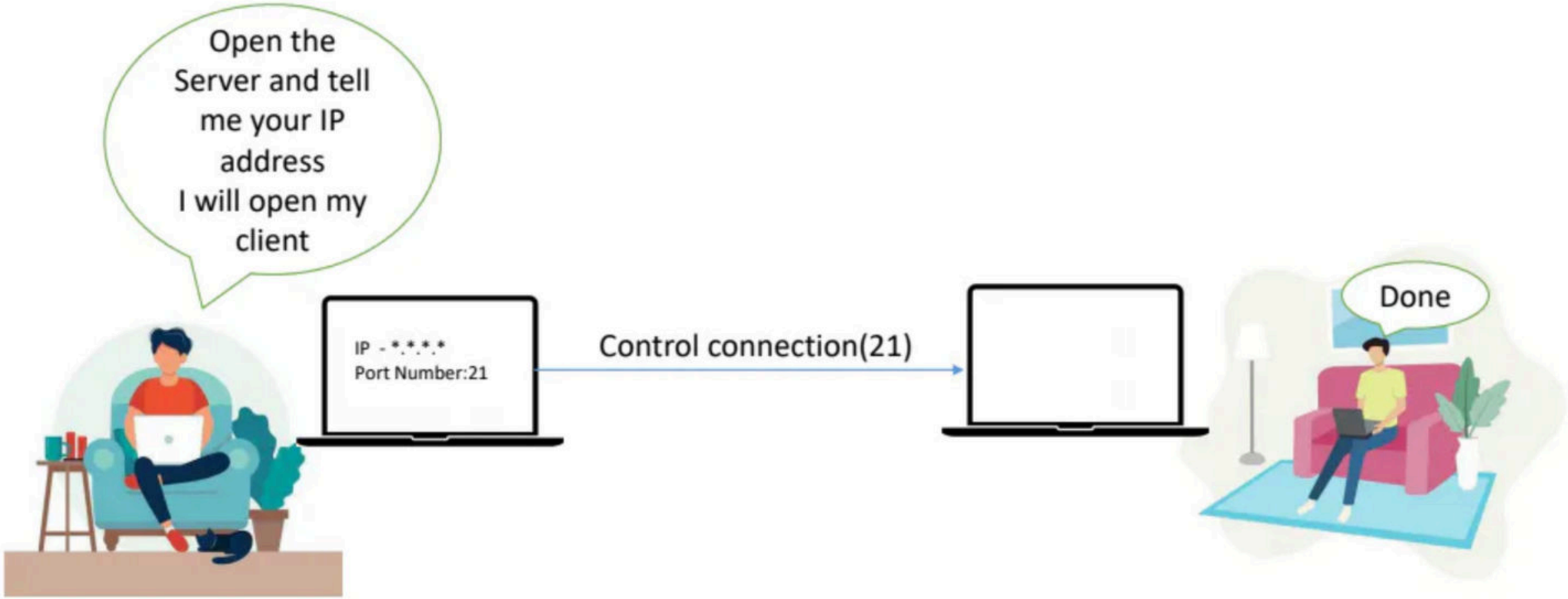
FTP

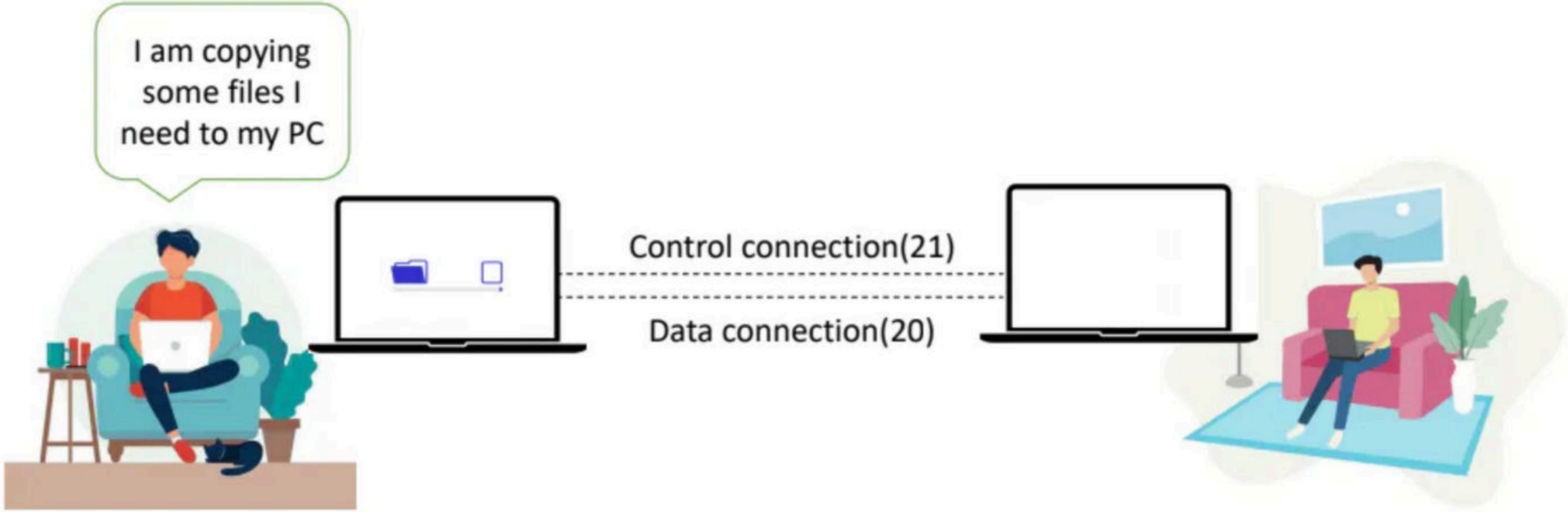
- FTP is short for File Transfer Protocol
- It is used for exchanging files over the internet.
- It enables the users to upload and download the files from the internet.
- FTP uses TCP at the transport layer.
- FTP uses port number 21 for control connection.
- FTP uses port number 20 for data connection.
- FTP uses persistent TCP connections for control connection.
- FTP uses non-persistent connections for data connection.
- FTP is a connection oriented protocol.
- FTP is an out-of-band protocol as data and control information flow over different connections.
- FTP is a stateful protocol.



filezilla server
client




Open the Server and tell me your IP address I will open my client
IP - *.*.*.*
Port Number:21
Control connection(21)
Done


I am copying some files I need to my PC
Control connection(21)
Data connection(20)

- FTP is the standard protocol provided by TCP/IP for copying a file from one host to another.

Although transferring files from one system to another seems simple and straightforward, some problems must be dealt with first.

Ex: Two systems may use different file name conventions

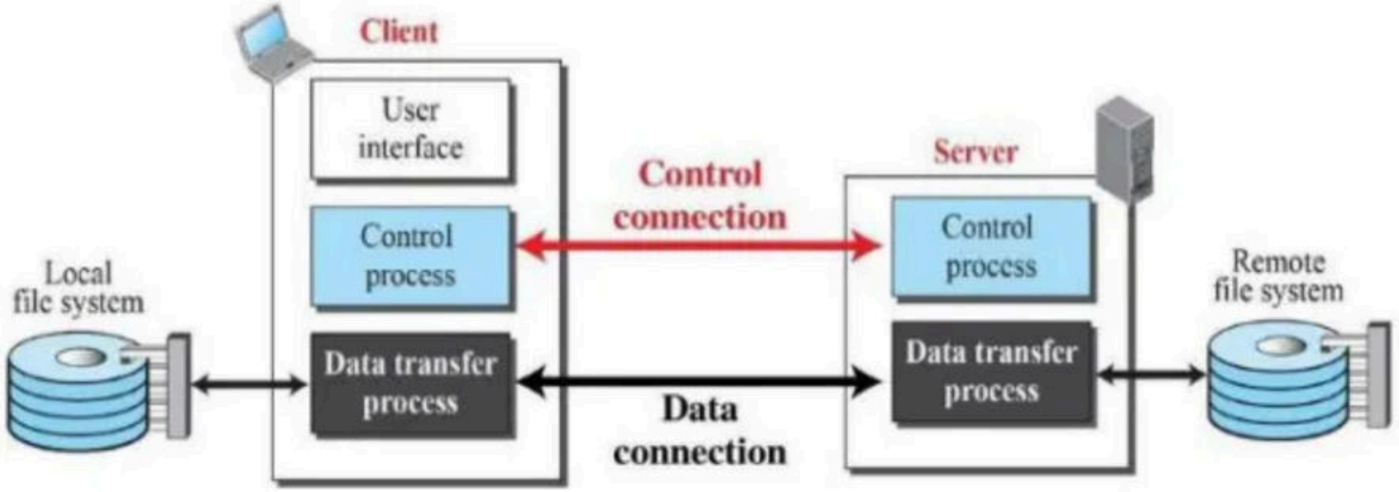
Two systems may have different ways to represent data.

Two systems may have different directory structures.

All of these problems have been solved by FTP in a very simple and elegant approach.

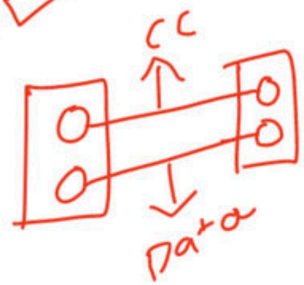
Although we can transfer files using HTTP, FTP is a better choice to transfer large files or to transfer files using different formats

Basic model of FTP



- **The server has two components**: 1. The server control process.
  2. The server data transfer process

The control connection is made between the control processes
The data connection is made between the data transfer processes.



Separation of commands and data transfer makes FTP more efficient.
The control connection uses very simple rules of communication.
We need to transfer only a line of command or a line of response a time.
The data connection, on the other hand, needs more complex rules due to the variety of data types transferred.

Lifetimes of Two connections

The two connections in FTP have different lifetimes.
The control connection remains connected during the entire iterative FTP session.
The data connection is opened and then closed for each file transfer activity.
It opens each time commands that involve transferring files are used, and it closes when the file is transferred.

-> When a user starts an FTP session, the control connection opens.
While the control connections is open, the data connection can be opened and closed multiple times if several files are transferred.

Some FTP commands

Command	Argument(s)	Description
ABOR		Abort the previous command
CDUP		Change to parent directory
CWD	Directory name	Change to another directory
DELE	File name	Delete a file
LIST	Directory name	List subsidiaries or flies
MKD	Directory name	Create a new directory
PASS	User password	Password
PASV		Server chooses a port
PORT	Port identifier	Client chooses a port
PWD		Display name of current directory
QUIT		Log out of the system
RETR	File name(s)	Retrieve files; files are transferred from server to client
RNFR	File name(old)	Identify a file to be renamed

Continued.....

Command	Argument(s)	Description
RNTO	File name (new)	Rename the file
SNOR	File name(s)	Store files; file(s) are transferred from client to server
STRU	F, R, or P	Define data organization (F: file, R: record, or P: page)
TYPE	A, E, I	Default file type (A: ASCII, E: EBCDIC, I: image)`
USER	User ID	User information
MODE	S,B, or C	Define transmissionbhhhj

Some responses in FTP

Code	Description	Code	Description
125	Data connection open	250	Request file action OK
150	File status OK	331	User name OOK; password is needed
200	Command OK	425	Cannot open data connection
221	Service closing	452	Action aborted; insufficient storage
225	Data connection open	500	Syntax error; unrecognized command
226	Closing data connection	501	Syntax error in parameters or arguments
230	User login OK	530	User not logged in

Data connection:

The data connection uses the well-known port 20 as the server site. However, the creation of a data connection is different from the control connection. The following shows the steps:

1. The client, not the server, issues a passive open using an ephemeral port. This must be done by the client because it is the client that issues the commands for transferring files.
2. The client sends this port umber to the server using the PORT command.
3. The server receives the port number and issues an active open using the well-known port 20 and the received ephemeral port number.

Communication over Data connection:

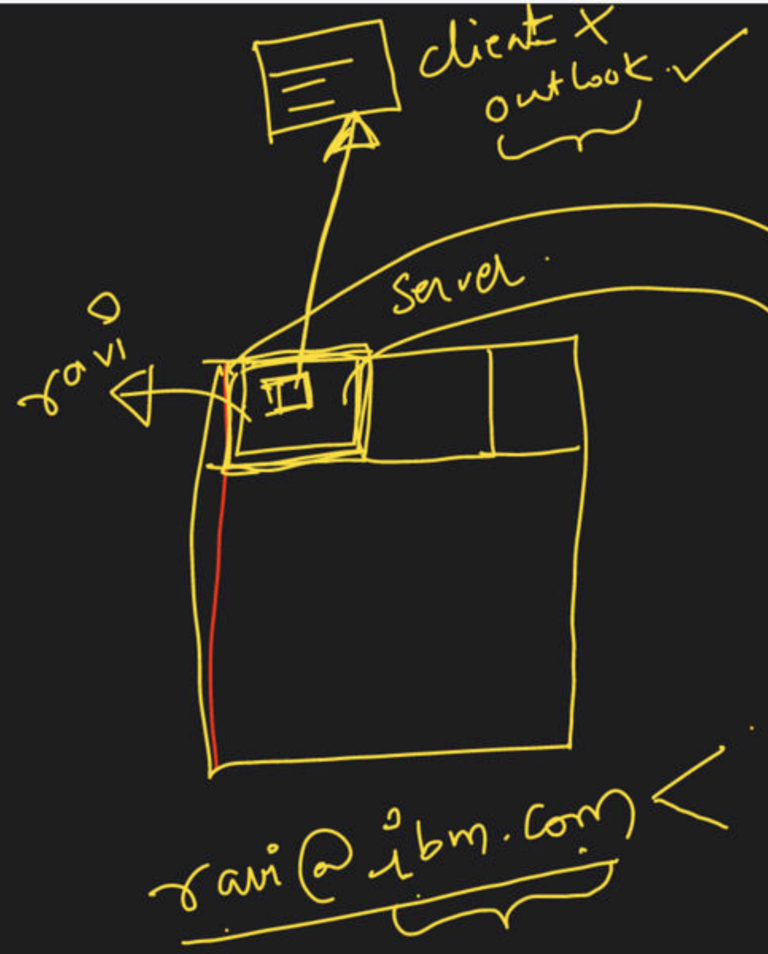
File type: ASCII file, EBCDIC file, or image file

Transmission Mode: Stream mode, Block mode, or compressed mode

Electronic Mail:

It is neither feasible nor logical for Bob to run a server program and wait until someone sends an email to him.

Bob may turn off his computer when he is not using it.



we

web based emails

gmail → http

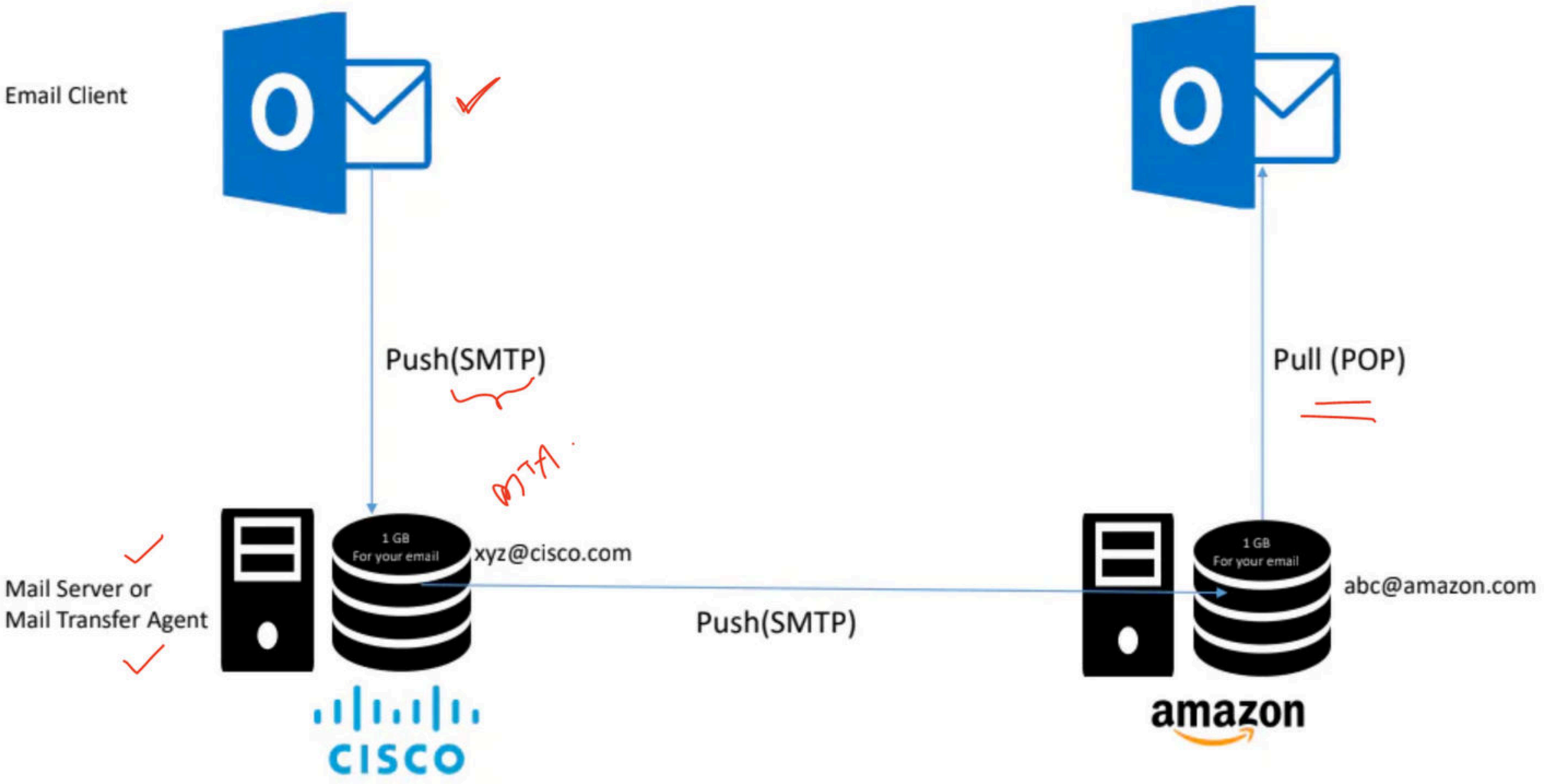
Computer Networks

SMTP - POP

SMTP and POP

- SMTP is short for Simple Mail Transfer Protocol.
- It is an application layer protocol.
- It is used for sending the emails efficiently and reliably over the internet.
- SMTP is a push protocol.
- SMTP uses TCP at the transport layer.
- SMTP uses port number 25.
- SMTP uses persistent TCP connections, so it can send multiple emails at once.
- SMTP is a connection oriented protocol.
- SMTP is an in-band protocol.
- SMTP is a stateless protocol.

- POP is a pull protocol.
- POP uses TCP at the transport layer.
- POP uses port number 110.
- POP uses persistent TCP connections.
- POP is a connection oriented protocol.
- POP is an in-band protocol.
- POP is a stateful protocol until the mail is downloaded as well as stateless across sessions.

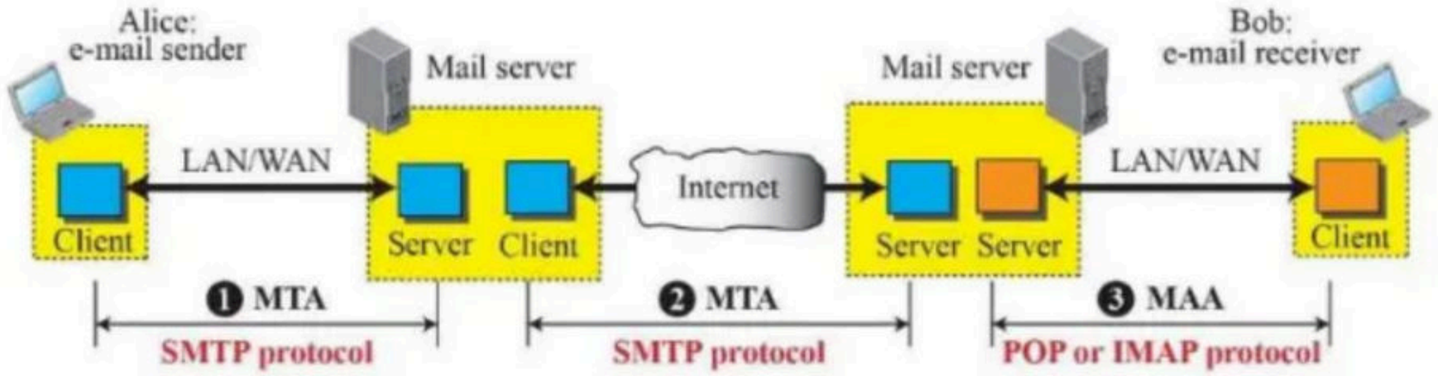

Email Client
Push(SMTP)
MTA
Pull (POP)
Mail Server or
Mail Transfer Agent
1 GB
For your email
xyz@cisco.com
Push(SMTP)
1 GB
For your email
abc@amazon.com
CISCO
amazon

Multipurpose Internet Mail Extension (MIME) Protocol

Later people needed to send images, videos, graphs and basically all types of non text content
For that purpose we moved on to MIME

- MIME is able to send multiple attachments with a single message.
- Unlimited message length.
- Binary attachments (executables, images, audio, or video files) which may be divided if needed.

Protocols used in electronic mail:



POP 3: Two modes

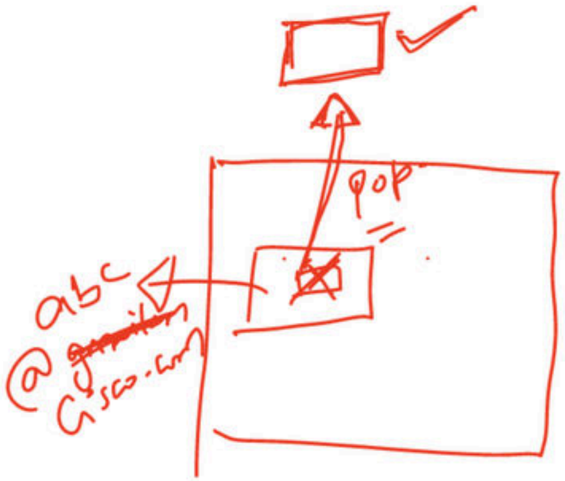
i) Delete mode: The mail is deleted from the mail box after each retrieval.

Normally used when the user is working at her permanent computer and can save and organize the received mail after reading or replying.

ii) Keep mode: The mail remains in the mailbox after retrieval.

Normally used when the user accesses his mail away from his primary computer.

The mail is read but kept in the system for later retrieval and organizing.



IMAP4:

Another mail access protocol is Internet Mail Access Protocol, version 4 (IMAP4). IMAP4 is similar to POP3, but it has more features; IMAP4 is more powerful and more complex.

POP 3 is deficient in the following ways:

- Does not allow user to organize her mail on the server.
- The user cannot have different folders on the server.
- Does not allow the
- User to partially check the contents of the mail before downloading.

IMAP4 provides the following extra functions

- A user can check the e-mail header prior to downloading.
- A user can search the contents of the e-mail for a specific string of characters prior to downloading.
- A user can partially download e-mail. This is , or rename mailboxes in a folder for e-mail storage useful if bandwidth is limited and email contains multimedia with high bandwidth requirements.
- A user can create, delete, or rename mailboxes in a folder for e-mail storage.

INTRODUCTION

- HTTP is an acronym for Hypertext Transfer Protocol . It is an application layer protocol in the TCP/IP protocol suite.
- WWW is repository of resources (web pages) stored in different computers all over the world. The primary purpose of HTTP is to transfer web pages from one computer (web server) to another computer(web client).
- HTTP can be used to access virtually all types of resources on the web. It allows us to transfer a wide variety of data such as text ,image ,audio , video and even the result of a query.

WEB SERVERS AND CLIENTS

- HTTP protocol is basically a request- response protocol between clients and servers.
- According to this protocol , a process is run which creates and stores resources such as HTML files, images ,etc. This process provides the resources on request and is called a web server or HTTP server.

To access resources stored on the web server, a process is designed to communicate with the server. The process is called web client or user agent.

- Web browsers are nothing but those web clients . They use HTTP protocol to communicate with web server to access resources specified by the URL at the address bar of the web browsers.

- Web servers typically runs on port 80 though any available port number may be used.

In TCP/IP protocol suite, a process in a machine is assigned a locally unique positive integer called port number.

- IP address together with the port number uniquely identifies a process all over the world.

So, IP address together with the port number uniquely identifies a process all over the world. This (IP address , port) pair is called a socket address of the process . To communicate with a web server , web clients need to specify the socket address of the web server.

URL AND ITS ANATOMY

A resource on the web is identified by an address called Uniform Resource Locator (URL).

An HTTP URL has the following form:

protocol : //host : [port]/[path[? params] [#anchor]]

protocol : //host : [port]/[path[? params] [#anchor]]

It indicates the protocol to be used for this URL. For HTTP URL , the protocol is http. Other possible protocols are ftp, gopher, mailto ,news ,nntp , telnet , wais ,file and prospero.

protocol : //host : [port]/[path[? params] [#anchor]]

This is the Fully Qualified Domain Name (FQDN) or the IP address of the computer where the web server runs.

Domain names are case –insensitive .So, www.google.com and WWW.GOOGLE.COM refer to the same host.

protocol : //host : [port]/[path[? params] [#anchor]]

Web servers typically run on port 80, if no port is specified ,port 80 is assumed.

protocol : //host : [port]/[path[? params] [#anchor]]

- This is the location of a file or a program (CGI ,Perl ,PHP ,JSP , etc) on the server relative to a document root specified by the web server. The document root is a directory where resources are stored.
- In the Apache web server ,the document root is usually set to /var /www/html. However , it can be configured.

protocol : //host : [port]/[path[? params] [#anchor]]

- This portion of the URL contains the parameters to be passed to web applications such as CGI, PERL, PHP or JSP.

- The path and params are separated by ? character. The params consists of a (name=value) pair separated by an ampersand(&).

For example, login= ukr&sid=145321& page=inbox specifies three parameters , login, sid and page whose values are “ukr ”, “145321” and “inbox” respectively.

- The server - side program typically extracts this information from the URL for processing.

protocol : //host : [port]/[path[? params] [#anchor]]

This part indicates a specific location in the web page. For example, #appendix specifies the appendix section of the web page. This location is created using <a> tag as follows:

<a name="appendix"> Appendix </a>
The named section can then be referred to as :
http:// www.it.jusl.ac.in/httphelp.htlm#appendix

URL EXAMPLE

protocol host

http://www.unacademy.com

protocol host port path

http://www.unacademy.com:8080/@ravula

protocol host port path

http://123.456.789.012:8080/@ravula

protocol host port path anchor

http://www.unacademy.com:8080/@ravula#subscribe

protocol host port path anchor params

http://www.unacademy.com:8080/@ravula#subscribe?referral_code=rrcs

MESSAGE FORMAT

It specifies a set of rules that clients and servers use to communicate:

- An HTTP server process is created on a port (usually 80) , which waits for clients to establish a TCP connection.

- An HTTP client initiates a TCP connection with the HTTP server (process) at the designated port.

- The HTTP server accepts this connection.

- The HTTP client then sends a request for a resource to the server.

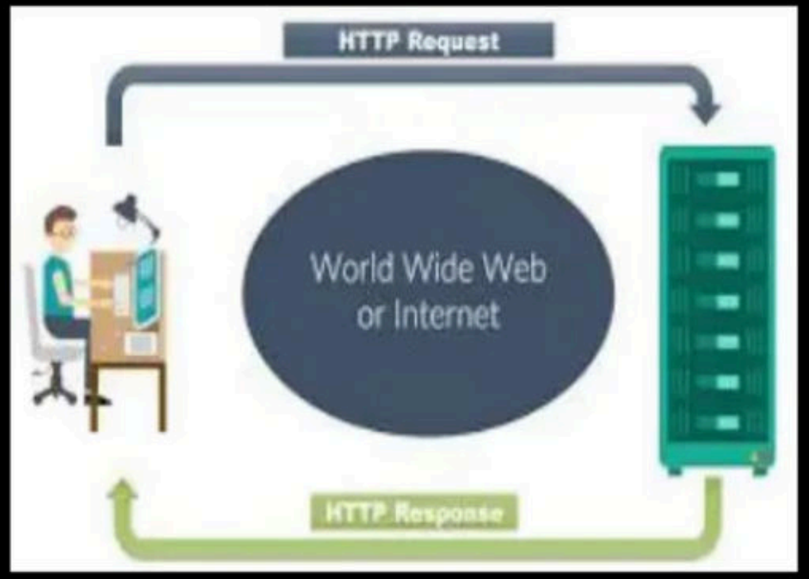
- Upon receiving the request , the server processes the request ,performs the desired task, and sends a response back to the client.

- The HTTP server closes the TCP connection.

- The HTTP client receives the response containing information and processes it.

Note that every time the HTTP client wants to get resource from the server, it has to follow these steps .

This makes HTTP stateless .This means that web server treats every request as a new request . There is no way to specify that some requests are related.



REQUEST MESSAGE

A request message is sent by a web client to the web server . It consists of the following parts:

- A request line.
- A header.
- An empty line.
- An optional body.

Request line
Header
Empty Line
Body(available for some messages)

HTTP request message format

REQUEST LINE

A request line consists of three parts : request type, URL, and HTTP version . Two consecutive parts are separated by a space.

Request Type		**URL**		**HTTP Version**

REQUEST TYPE (METHOD)

- It indicates the type of request , a client wants to send. They are also called methods.
- A method makes a message either a request or a command to the server.
- Request messages are used to retrieve data from the server whereas a command tells the server to do a specific task.

GET

- This is the most frequently used method in the WWW. It is specified when client wants to retrieve (GET) a resource(document) from the server.
- The URL in the request line identifies the resource . If the URL specified is a valid one , the server reads the content of the resource and sends the content back to the client; otherwise an error message is sent back to the client.
- If the resource being requested is a server-side program such as CGI script or ASP or JSP , the result generated by the program is returned instead of the content of the resource.
- The message body is empty for the GET method.
- The GET method may be a “conditional GET” method. In such a case, the request message includes an “If-Modified-Since” header that specifies a date . This header specifies that the identified resource has to be transferred only if it is modified after the specified date. So users can avoid downloading resources that were downloaded on some earlier date and have not been modified since.
- The conditional GET method effectively reduces network bandwidth and helps increasing network performance.

HEAD

- It is used when the client wants to know the header information (meta-information) about a resource but not the resource content.

POST

- It is used when a client wants to send (POST) some information (possibly large) to the server.
- The actual information is included in the body part of the request message instead of appending it to the URL as done in the GET method.
- The headers describe the message body such as content type and content length.
- The commonest form of the POST method is to submit an HTML form to the server.

PUT

- It is used to upload a new resource or replace an existing document. The actual document is specified in the body part.
- As the PUT method can modify or replace an existing document, it is vulnerable and is not permitted by most of the web servers.
- However, it is not recommended to configure web servers in such a way without any valid reasons.

PATCH

- This is similar to PUT method except that it specifies a list of differences that must be applied on the existing file.

COPY

- The HTTP protocol may be used to copy a file from one location to another.
- The method COPY is used for this purpose. The URL specified in the request line specifies the location of the source file.
- The location of the target file is specified in the entity header.
- Note that the target web server must be configured properly to accept the COPY method.
- This method is also vulnerable.

MOVE

- It is similar to the COPY method except that it deletes the source file.
- The location of the source file is specified by the URL in the request line.
- The entity header specifies the location of the target file.
- Note that the target web server must be configured properly to accept the MOVE method.
- This method is also vulnerable.

DELETE

- This method is used to remove a document from the server.
- The location of the document to be deleted is specified by the URL in the request line.
- This method is vulnerable.

LINK

- This is used to create a link or links from one document to another.
- The URL in the request line specifies the location of the source file and the entity header specifies the location of the target document.

UNLINK

- It is used to remove a link or links created by the LINK method.

OPTIONS

- It is used to retrieve the set of methods supported by the server.
- It is used to check whether a server is functioning properly before performing other tasks.
- It is used to check whether the web server really supports a method before actually using that method.

CONNECT

- It is used to convert a request connection into the transparent TCP/IP tunnel.
- It is usually done to facilitate Secured Socket Layer(SSL) encrypted communication(eg HTTPS) through an unencrypted HTTP proxy server.

TRACE

- It is used to instruct the web server to echo the request back to the client.
- The client can then see what additions or change are done by the immediate servers.

SAFE AND UNSAFE METHODS

- Among the methods discussed ,some methods such as GET ,HEAD, OPTIONS and TRACE are used only to retrieve information from the server . Such methods are called safe. They cannot change the state of the server . This means, they do not have any harmful side effects such as caching ,logging ,etc .
- On the other hand, methods such as DELETE,MOVE,UNLINK take actions that may change the state of the server.

These methods have harmful side effects and hence are vulnerable. Sensitive web servers are usually not configured to accept these methods.

HTTP VERSIONS

This field specifies the version of the HTTP protocol being used. It can have the following values: HTTP/1.0 and HTTP/1.1 .

The current version is HTTP/1.1.

RESPONSE MESSAGE

In response to the request message , a response message is sent by a server to the client. It consists of the following parts:

- A status line
- A header
- An empty line
- An optional body

Status line
Header
Empty Line
Body(available for some messages)

HTTP response message format

STATUS LINE

Status line consists of three parts: HTTP version ,Status code and Status phrase. Two consecutive parts are separated by a space.

HTTP Version		**Status Code**		**Status Phrase**

STATUS CODE

It is a three –digit code that indicates the status of the response. The status codes are classified with respect to their functionality into five groups:

- 1 xx series (Informational) – This class of status codes represents provisional responses.
- 2 xx series (Success) – This class of status codes indicates that the client's requests are received, understood and accepted successfully.
- 3xx series(Redirectional) – These status codes indicates that additional actions must be taken by the client to complete the request. The user agent may take further actions in order to fulfill the request automatically provided that it uses either the HEAD or the GET method.
- 4xx series(Client error) – These status codes are used to indicate that the client request had an error and therefore it cannot be fulfilled. Except for the HEAD method, the body of the response message contains the explanation that caused the error. The user agent should display the error message to inform the user.
- 5xx series(Server Error) – This set of status code indicates that the server encountered some problem and hence the request cannot be satisfied at this time. The reason of the failure is embedded in the message body . It also indicates whether the failure is temporary or permanent.

HEADERS

- HTTP headers are very important part of both request message and response message.
- They collectively specify the characteristics of the resource requested and the data that are provided.
- For Example, a client may want to accept image files only in specified format.
- The headers are separated by an empty line from the request and response body.

General Header
Request Header
Entity Header

HTTP Request Header Format

General Header
Response Header
Entity Header

HTTP Response Header Format

Computer Networks

Devices in Computer Networks

CABLES

The cable is a physical media, through which an analog and digital data transfer take place

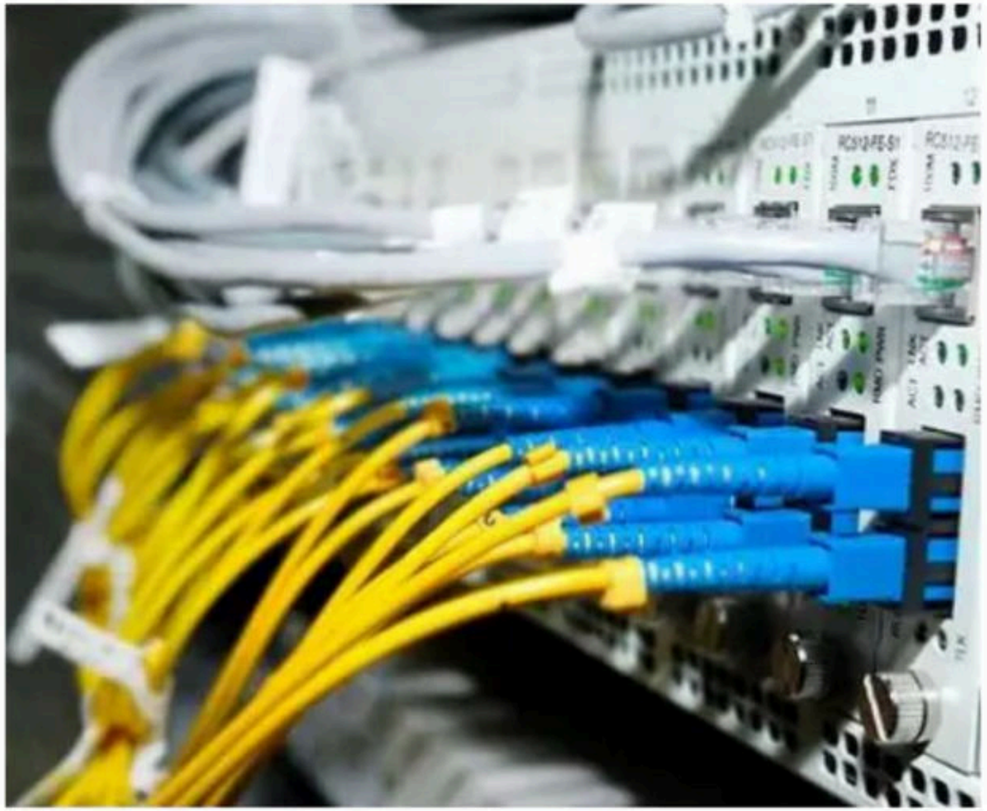
Types of Cables

- Twisted pair
- Coaxial
- Optical fiber

Operate at Physical Layer.

Have a problem of attenuation.

Collisions possible (Collision Domain is n)



REPEATER

A repeater operates at the physical layer.

Its job is to regenerate the signal over the same network before the signal becomes too weak or corrupted so as to extend the length to which the signal can be transmitted over the same network.

An important point to be noted about repeaters is that they do not amplify the signal.

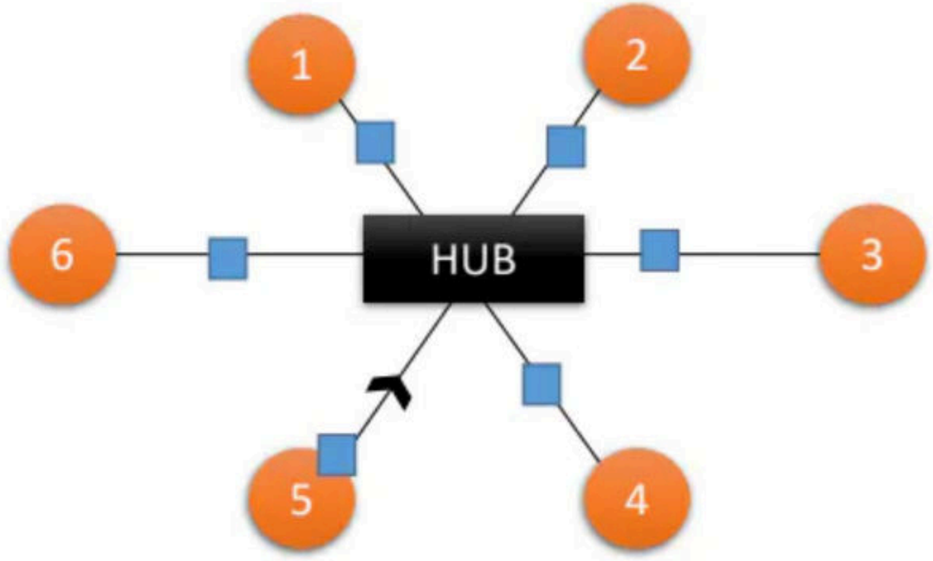
When the signal becomes weak, they copy the signal bit by bit and regenerate it at the original strength.

It is a 2 port device.

Collisions possible

HUBS

- A hub is basically a multiport repeater.
- A hub connects multiple wires coming from different branches
- Hubs cannot filter data, so data packets are sent to all connected devices.
- Traffic is High
- Collision are possible

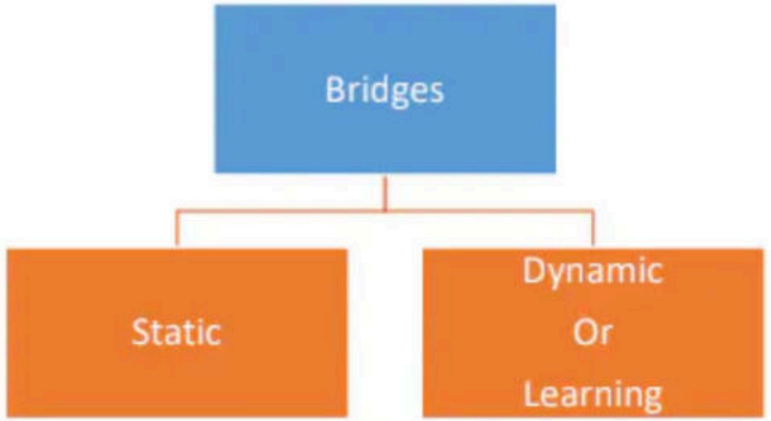


BRIDGE

- A bridge operates at Physical and data link layer.
- A bridge is a repeater, with add on the functionality of filtering content by reading the MAC addresses of source and destination.
- Features in include Filtering ,forwarding and flooding
- It is also used for interconnecting two LANs working on the same protocol.
- Collision Domain is reduced
- Store and Forward

BRIDGE

MAC	PORT
1	a
2	a
3	a
4	b
5	b
6	b



SWITCH

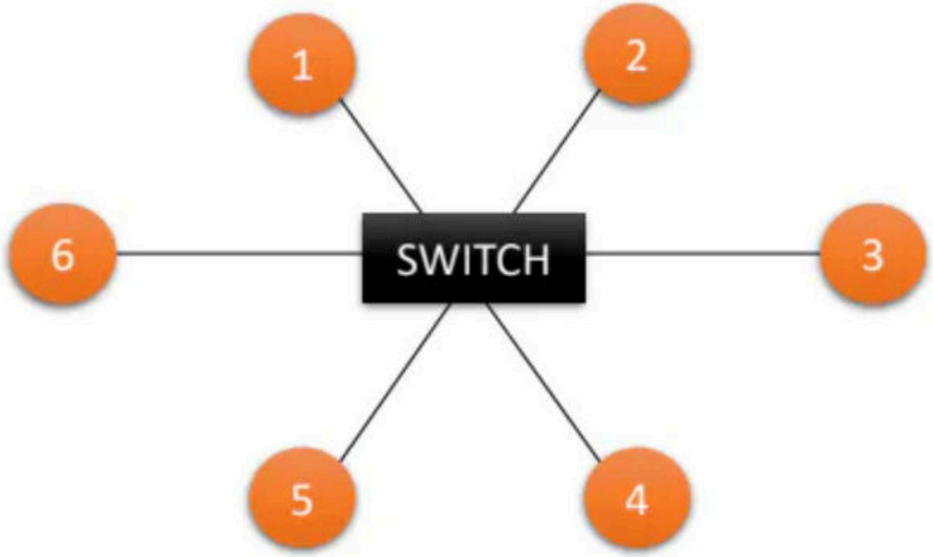
A switch is a multiport bridge with a buffer and a design that can boost its efficiency(a large number of ports imply less traffic) and performance.

A switch is a Physical and data link layer device.

The switch can perform error checking before forwarding data, that makes it very efficient as it does not forward packets that have errors.

No collisions

Traffic is low



ROUTER

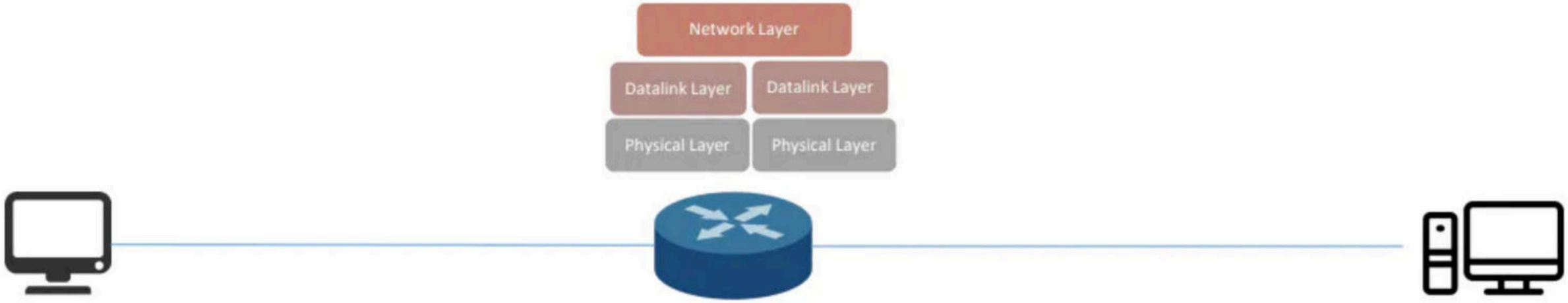
A router is a device that routes data packets based on their IP addresses.

Router is mainly a Network Layer device.

Routers normally connect LANs and WANs together and have a dynamically updating routing table based on which they make decisions on routing the data packets.

Features include Filtering, Flooding and Forwarding

No collisions



DEVICES	COLLISION DOMAIN	BROADCAST DOMAIN
Repeater	Same	Same
Hub	Same	Same
Bridge	Same	Reduces
Switch	Same	Reduces
Routers	Reduces	Reduces

Computer Networks

Revision of Application Layer and GATE Questions Part 3

REVISION

	DNS	HTTP	SMTP	POP	FTP
Stateful / Stateless	Stateless	Stateless	Stateless	Stateful	Stateful
Transport Protocol Used	UDP	TCP	TCP	TCP	TCP
Connectionless / Connection Oriented	Connectionless	Connectionless	Connection Oriented	Connection Oriented	Connection Oriented
Persistent / Non-persistent	Non-persistent	HTTP 1.0 is non-persistent. HTTP 1.1 is persistent.	Persistent	Persistent	Control connection is persistent. Data connection is non-persistent.
Port Number Used	53	80	25	110	20 for data connection. 21 for control connection.
In band / Out-of-band	In band	In band	In band	In band	Out-of-band

1.) Consider a TCP connection between a client and a server with the following specifications: the round trip time is 6 ms, the size of the receiver advertised window is 50 KB, slow start threshold at the client is 32 KB, and the maximum segment size is 2 KB. The connection is established at time t=0. Assume that there are no timeouts and errors during transmission. Then the size of the congestion window (in KB) at time t+60 ms after all acknowledgements are processed is _____. [GATE 2020]

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SOLUTION:
Threshold = 32 Kb, MSS = 2KB, RTT = 6ms
Here, t + 60 is nothing but at the 10 RTT (60/6 = 10), but here
it's asking after all acknowledgement are processed it means
after the 10th RTT, .i.e at the 11RTT
1st transmission: 2 KB
2nd transmission: 4 KB
3rd transmission: 8 KB
4th transmission: 16 KB
5th transmission: 32 KB (Threshold reached)
6th transmission: 34 KB
7th transmission: 36 KB
8th transmission: 38 KB
9th transmission: 40 KB
10th transmission: 42 KB
At the completion of 10th transmission RTT = 10*6 = 60 ms
For the 11th transmission, The congestion window size is 44 KB

2.)Consider the following statements regarding the slow start phase of the TCP congestion control algorithm. Note that cwnd stands for the TCP congestion window and MSS denotes the Maximum Segment Size.

(i) The cwnd increase by 2 MSS on every successful acknowledgement.
(ii) The cwnd approximately doubles on every successful acknowledgedment.
(iii) The cwnd increase by 1 MSS every round trip time.
(iv) The cwnd approximately doubles every round trip time.
Which one of the following is correct?

A.)Only (ii) and (iii) are true
B.)Only (i) and (iii) are true
C.)Only (iv) is true
D.)Only (i) and (iv) are true [GATE 2018]

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SOLUTION:
In Slow-start, the value of the Congestion Window will be increased by 1 MSS with each acknowledgement (ACK) received, and effectively doubling the window size each round-trip time
Initially, TCP starts with cwnd of 1 MSS. On every ack, it increases cwnd by 1 MSS.
That is, cwnd doubles every RTT.
Initially sends 1 segment. On ack, sends 2 segments.
After these 2 acks come back, sends 4 segments etc.
TCP rate increases exponentially during slow start.
Slow start continues till cwnd reaches threshold.
After threshold is reached, cwnd increases more slowly, by one 1 MSS every RTT.

3.) Which one of the following protocols is NOT used to resolve one form of address to another one?

A.)DNS
B.)ARP
C.)DHCP
D.)RARP [GATE 2016]

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SOLUTION:
DHCP is dynamic host configuration protocol: allocates one of the unused IP address.
Except DHCP, remaining all the protocols are used to resolve one form of address to another one.
I. DNS is going to convert hostname to IP address.
II. ARP is going to convert IP to MAC.
III. DHCP is going to assign IP dynamically.
IV. RARP is going to convert MAC to IP.

4.)Which of the following is/are example(s) of stateful application layer protocols?
(i) HTTP
(ii) FTP
(iii) TCP
(iv) POP3
A.) (i) and (ii) only
B.) (ii) and (iii) only
C.) (ii) and (iv) only
D.) (iv) only [GATE 2016]

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D.) (iv) only [GATE 2016]

SOLUTION:
Stateless protocol is a communications protocol in which no information is retained by either sender or receiver.
A protocol that requires keeping of the internal state on the server is known as a stateful protocol.
Stateless - HTTP, IP
Stateful - FTP, SMTP, POP3, TCP
TCP is stateful as it maintains connection information across multiple transfers, but TCP is a Transport layer protocol.
FTP and POP3 is stateful Application layer protocol.

5.)For a host machine that uses the token bucket algorithm for congestion control, the token bucket has a capacity of 1 megabyte and the maximum output rate is 20 megabytes per second. Tokens arrive at a rate to sustain output at a rate of 10 megabytes per second. The token bucket is currently full and the machine needs to send 12 megabytes of data. The minimum time required to transmit the data is seconds _____. [GATE 2016]

A.)1.1 sec

B.)1.2 sec

C.)1.3 sec

D.)1.4 sec

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D.)1.4 sec

SOLUTION:

According to the token bucket algorithm, the minimum time required sending 1 MB of data or the maximum rate of data transmission is given by:

S = C / (M - P)

Where,

M = Maximum output rate,

C = capacity of the bucket,

P = Rate of arrival of a token,

Given, M=20 Mb, C=1Mbps, P=10 Mbps

Therefore, S= 1 Mb / (20-10) Mbps = 1/10 = 0.1 sec

Since, the bucket is initially full, it already has 1 Mb to transmit so it will be transmitted instantly.

So, we are left with only (12 – 1) Mb, i.e. 11 Mb of data to be transmitted.

Therefore, time required to send the 11 MB will be 11 * 0.1 = 1.1 sec