4/4/22

MODULE - 1

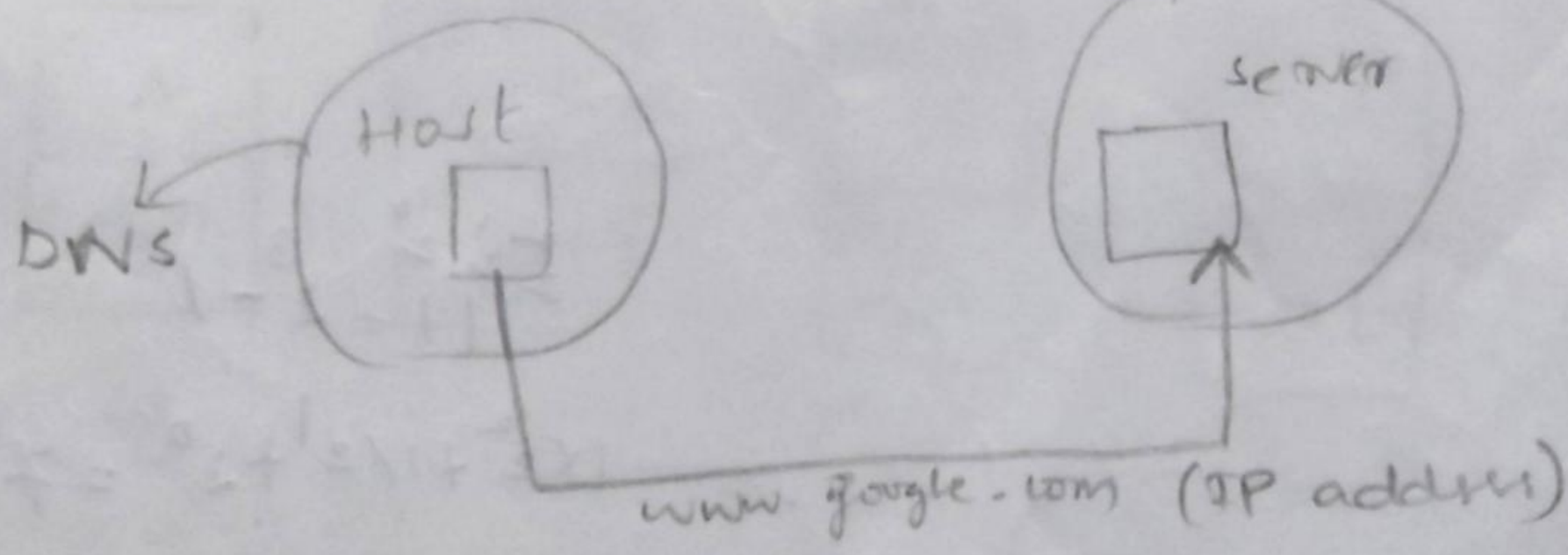
1st mod - physical layer
Datalink layer
Network layer
Transport layer
Application layer

Host → Identify network → Identify host → server
↓
Port number = Identify which progseam is running

Client = process requesting for service
Server = Process which providing service

for each host / network there is an IP address
for obtaining that IP address need to access DNS
(Domain Name Server)

for accessing network or get services give IP address
to server.



IP - Internet Protocol

IP-address - 32 bit - 2 parts (n bits)

1) Network ID (K) NID
2) Host ID HID (n-k)

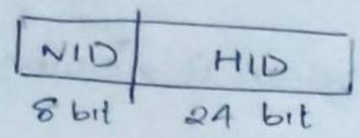
Network ID - from IP address ^ will get which network

HID - will get ^ which host H has to go

for K NID, there are 2^k Networks

IANA

Internet Assign Number



in 1980

disadvantages

This static div
- is not applicable for small organisation
- Host get wastes - number of NID is less
- Not feasible

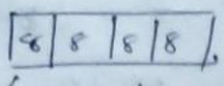
Another dynamic division called Classful Addressing depends on our application and number of host we can buy classes

$2^2 2^1 2^0$

$111 = 2^3 - 1$

$1\times2^2 + 1\times2^1 + 2^0 = 7$

7/4/22

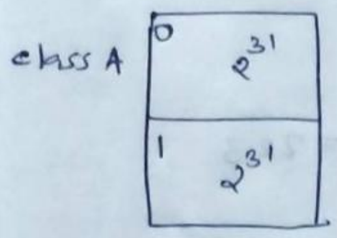
IP address - 32 bit  octat

comes to each bit there is a decimal

decimal dotted notation - 1.160.10.240

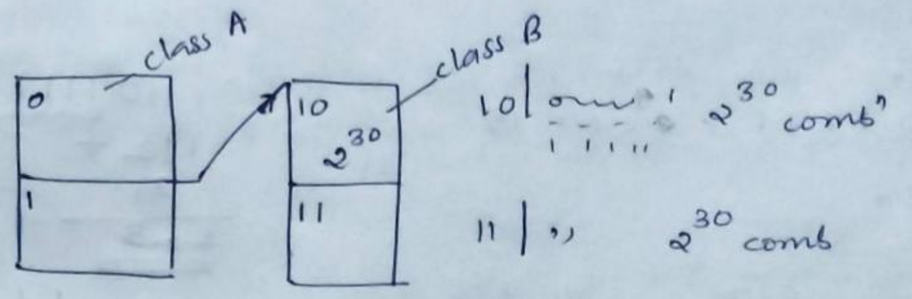
diff type of classful addressing

IP - 2^{32} so 32 bit.



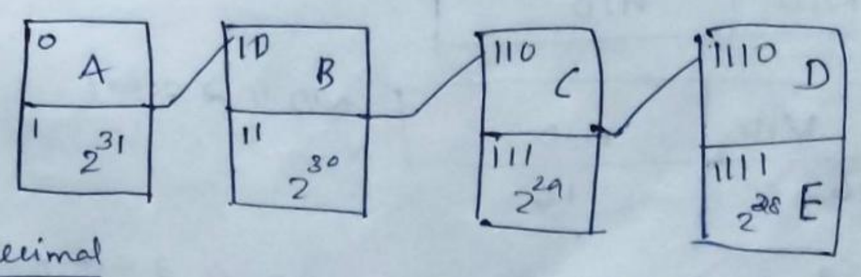
for 0| ... 2^{32} combinations

for 1| ... 2^{32} combination



10| ... 2^{30} comb'

11| ... 2^{30} comb



decimal

$1 \rightarrow 2^1 - 1 = 1$

$11 \rightarrow 2^2 - 1 = 3$

$111 \rightarrow 2^3 - 1 = 7$

$1111 = 2^4 - 1 = 15$

$11111 = 2^5 - 1 = 31$

out of first octant

Class A - 0 0 0 0 0 0 0 0

0 0 0 0 0 0 0 1

0 1 1 1 1 1 1 1 (7) $= 2^7 - 1 = 127$

Range of class A is 0 to 127

Class B

1 0 1 1 1 1 1 1 = $2^6 - 1$ = 64

range of class B is 12

1 0 1 1 1 1 1 1 = $2^7 - 1$ = 128

$2^6 + 2^7$ = 192

range : 128 – 191

110 + $2^5 - 1$

192 + 31 = 223

127 + 64 = 191

128 + 64 = 192

class B – 192 +

00 – 011111 + 2^6

Class C

1 1 0 1 1 1 1 1 = $2^5 - 1$ = 31

192 + 31 = 223

class C

191 + 2^5 = 223

192 – 223

Class – D

1 1 1 0 1 1 1 1 = $2^4 - 1$ = 15

223 +

1110 1111
192 +
31
223

Class A – [0 NID (8 bits) | HID (24 bits)] — NID is 1 octat

Class B – [10 NID (16) | HID (16)] — NID is 2 octat

Class C – [110 NID (24 bits) | HID (8 bits)] — NID is 3 octat

Class D – No NID, & HID
– used for multicasting

Class E – used for military purposes

A	0 – 127
B	128 – 191
C	192 – 223
D	224 – 239
E	240 – 255

128 + 64 + 32 = 224 + 15

we avoid 255

eg: 152 . 93 . 01 – class B
200 . 10 . 10 . 1 – C
10 . 59 . 135 . 4 – A

network address of NID part is given with zeros in HID part

Host address part is given with zeros in NID part

we wont assign 190 . 5 . 0 . 0
190 . 5 . 255 . 255

ie why HID part will reduce by 2

for class A HID = $2^{24} - 2$, NID = 2^7

Class B HID = $2^{16} - 2$, NID = 2^{14}

Class C HID = $2^8 - 2$, NID = 2^{21}

Scanned by TapScanner

8/4/22

Casting

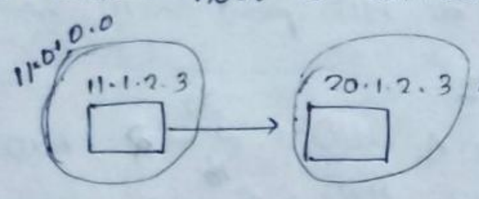
unicast multicast broadcast

limited broadcast directed broadcast

Data	Sousce Addsers	destination Address

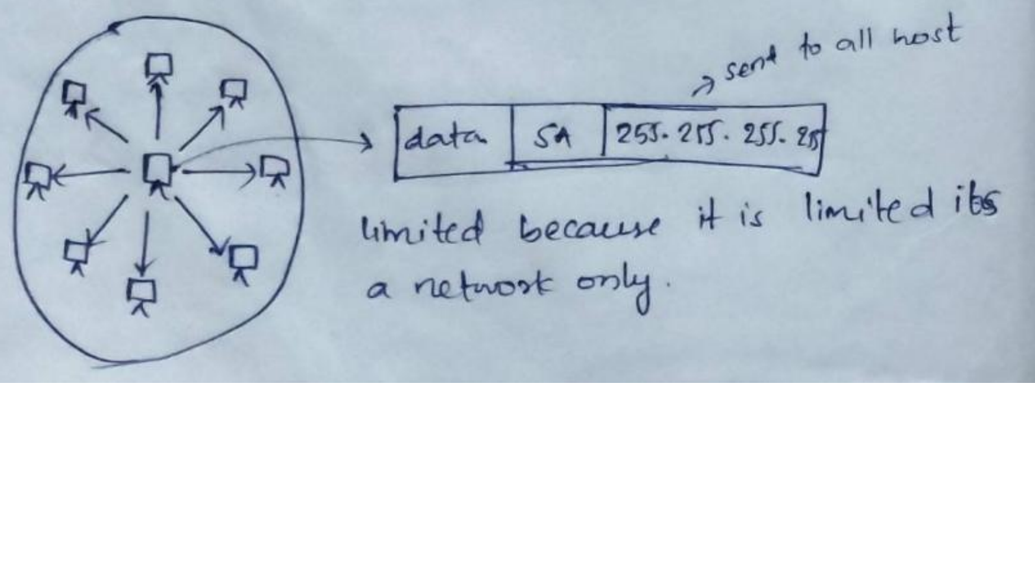
Unicast

Transmitting data from one source host to the one destination host is unicast. It is one to one transmission.



Limited broadcasting

Transmitting data from one source host to all other host residing in the same network is limited broadcast



limited because it is limited its a network only.

Direct Broadcast

- one source host to all other host residing in some other network.

Multicasting

- from one source host to a particular group of host having interest in receiving the data is multicast one to many transmission.

IP Address	Network ID	Limited broadcast address	Directed broadcast address
1.2.3.4	1.0.0.0	255.255.255.255	1.255.255.255
10.12.20.60	"	"	10. "
130.1.2.3	130.1.0.0	"	130.1.255.255
150.0.150.150	150.0.0.0	"	150.0.255.255
200.1.10.100	200.1.10.0	"	200.1.10.255
220.15.1.10	220.15.1.0	"	220.15.1.255
250.0.1.2	X	X	X
300.1.2.3	X	X	X

18/4/22

Subnetting

The whole network is divided called subnets
- easy to manage, security

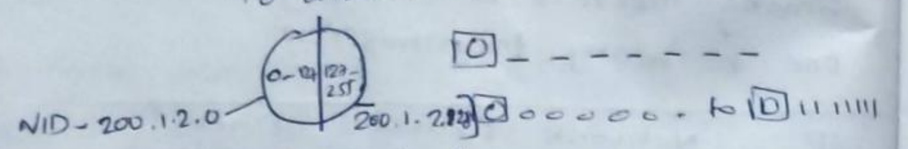
process of dividing a single network in to diff sub network is subnetting.

Network → ~~Add~~ Subnet → Host

NID HID
eg: To divide the network 200.1.2.0

divide ~~dont~~ only HID past

To divide in to two borrow 1 bit



To divide in to 4, borrow 2 bit.

0 0 - - - - - -

outside network NID is for whole network
otherwise it is the NID of a subnet.

Subnet Mask

for 2 subnets : 255.255.255.128

for 4 " : 255.255.255.192 { 192 = 64+128
11000000

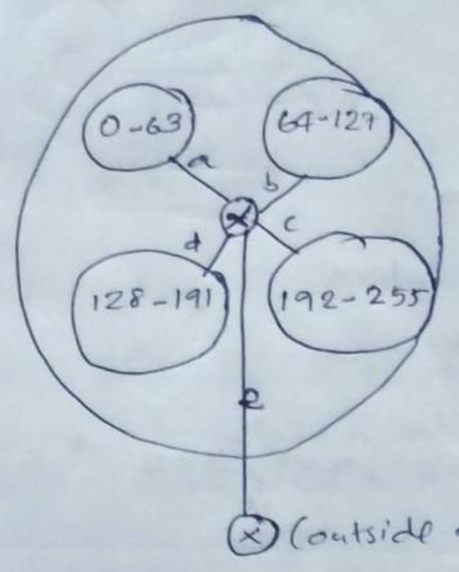
ANDing
Subnet mask ● IP gives NID.

- used for routing

eg: 255.255.255.192 → 11000000
AND 200.1.2.130 → 10000010
200.1.2.128 ← 10000000

any number ANDing with 255 gives that num

subnet mask
AD IP
gives NID of subnet



	NID	SM	Interface
a	200.1.2.0	255.255.255.192	a
b	200.1.2.64	"	b
c	200.1.2.128	"	c
d	200.1.2.192	"	d
e	0.0.0.0	0.0.0.0	e

isp provide (IP config, Hconfig)
- IP address
- subnet mask
- default gateway
- DNS

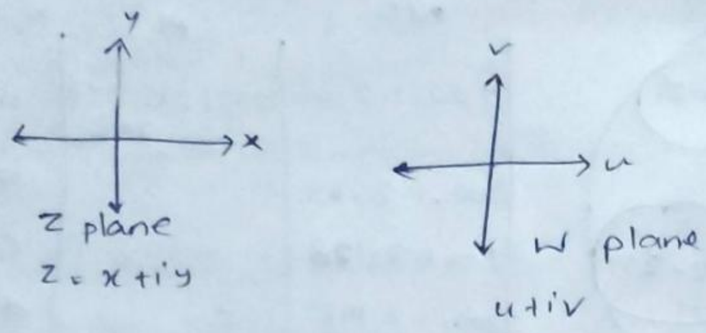
If HID comes within a subnet they can communicate directly without router.

To communicate with diff subnets or diff network router is used.

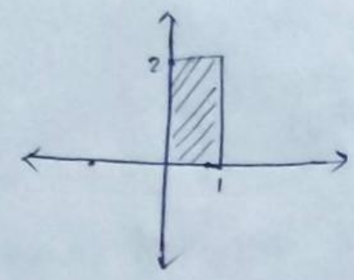
If SM is 255.255.255.255 means only communication is possible through router only.
- High security

18/9/22 Transformation of mapping

Wkt ~~transformation of mapping~~ function $f(z)$ can't be represent graphically



$f(z) = w = z + (1-i)$, z : $x=0, y=0, x=1, y=2$



$w = z + (1-i)$

$u+iv = x+iy+1-i$

$= x+1+i(y-1)$

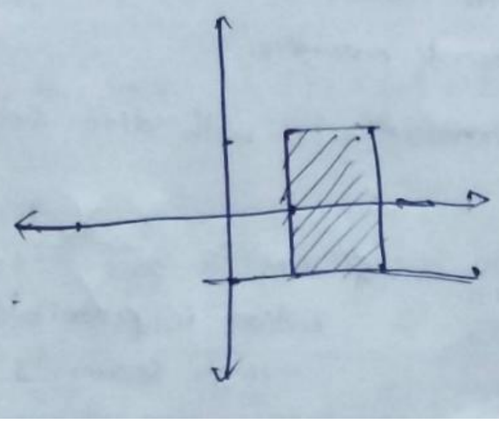
$u = x+1 \quad v = y-1$

$x=0, y=0$

$u=1 \quad v=-1$

$x=1, y=2$

$u=2 \quad v=1$



Conformal mapping

If $w=f(z)$ said to be conformal in z plane and angle θ made by two curves will be same angle θ in w (its image)

Pg no: 6 $f'(z) \neq 0$

$f'(z)$ is called critical point

Q for confirmal transformation $w = z^2$ ST

i) the coeff of magnification at $z = 1+i$ is $2\sqrt{2}$

ii) angle of rotation at $z = 1+i$ is $\pi/4$

$f(z) = z^2$

$f'(z) = 2z$

$f'(z)]_{z=1+i} = 2(x+iy)$

$= 2(1+i)$

$= 2+2i$

$= \sqrt{2^2+2^2} = \sqrt{8} = 2\sqrt{2}$

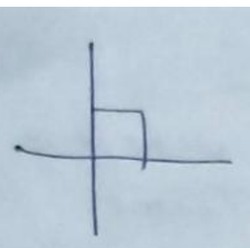
$f'(z)]_{z=1+i} = 2+2i$

$\tan^{-1}\left(\frac{y}{x}\right) = \tan^{-1}\left(\frac{2}{2}\right) = \tan^{-1}(1) = \pi/4$

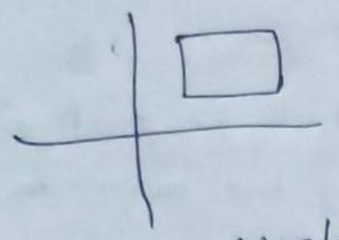
Q) $w = f(z) = z+c \quad c = a+ib$

$z = x+iy \quad f^*(z) = x+iy+a+ib$

$= x+a+i(y+b)$



z plane



w-plane

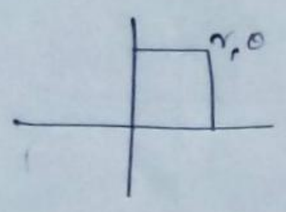
$w = cz$

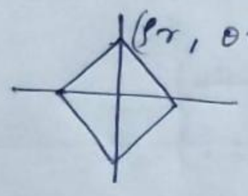
$z = re^{i\theta}$ $\quad c = \rho e^{i\alpha}$

$w = \rho e^{i\alpha}(re^{i\theta})$

$= \rho r\, e^{i(\alpha+\theta)}$

$w = R \cdot e^{i\phi}$ $\quad$ If $z = (r, \theta) \Rightarrow w = (\rho r, \theta+\alpha)$





Inversion

$w = \frac{1}{z}$

$z = re^{i\theta}$ $\quad w = \frac{1}{re^{i\theta}} = \frac{1}{r}e^{-i\theta}$ $\quad R = \frac{1}{r}$, $-\theta = \phi$

$w = Re^{i\phi}$

Z-plane circle is $x^2+y^2+2gx+2fy+c$

$w = \frac{1}{z}$ $\quad z = \frac{1}{w} = \frac{1}{u+iv}$

$x+iy = \frac{1}{u+iv} \times \frac{u-iv}{u-iv} = \frac{u-iv}{u^2+v^2}$

$x = \frac{u}{u^2+v^2}$ $\quad y = \frac{-v}{u^2+v^2}$

$x^2+y^2+2gx+2fy+c$

$w = \frac{1}{z}$ $\quad z = \frac{1}{w}$

$\left(\frac{u}{u^2+v^2}\right)^2 + \left(\frac{v}{u^2+v^2}\right)^2 + 2g\frac{u}{u^2+v^2} + 2f\frac{-v}{u^2+v^2} + c = 0$

$= \frac{u^2+v^2}{(u^2+v^2)^2} + \frac{2gu-2fv}{u^2+v^2} + c = 0$

$1 + 2gu - 2fv + c(u^2+v^2) = 0$

$c(u^2+v^2) + 2gu - 2fv + 1 = 0$

Q] ST by the transformation $z + \frac{1}{z}$ the circle in z plane $|z| = R$ where $R \neq 1$ is transformed into ellipse of w plane. What happens $|z| = 1$

$w = z + \frac{1}{z}$ $\quad z = re^{i\theta}$

$= re^{i\theta} + \frac{1}{re^{i\theta}}$ $\quad = r(e^{i\theta} + e^{-i\theta})$

$= r(\cos\theta + i\sin\theta) + \frac{1}{r}(\cos\theta - i\sin\theta)$

$= \left(r + \frac{1}{r}\right)\cos\theta + i\left(r - \frac{1}{r}\right)\sin\theta$

$u = \left(r + \frac{1}{r}\right)\cos\theta \qquad v = \left(r - \frac{1}{r}\right)\sin\theta$

$|z| = r$

$|re^{i\theta}| = r$

$= \sqrt{r^2\cos^2\theta + r^2\sin^2\theta} = r$

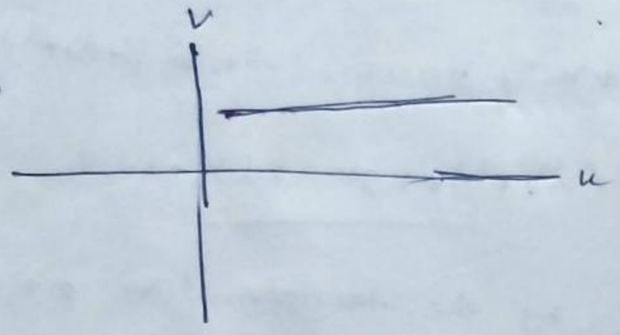
$= r\sqrt{\cos^2\theta + \sin^2\theta} = r$

$= \cos^2\theta + \sin^2\theta = 1$

$\left(\frac{u}{r + \frac{1}{r}}\right)^2 + \left(\frac{v}{r - \frac{1}{r}}\right)^2 = 1$ { form of ellipse $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$

If $r = 1$

$u = 2\cos\theta$, $v = 0$



Bilinear transformation combo of translation, rotation, inversion.

$w = \frac{az+b}{cz+d}$, $ad - bc \neq 0$

$w_1, w_2, w_3, w_4 : \frac{w_1 - w_2}{w_2 - w_3} * \frac{w_3 - w_4}{w_4 - w_1}$

Q] find the image of $|z-1| = 1$ under the mapping

$w = \frac{1}{z}$

$\Rightarrow |z| = \frac{1}{w} = \frac{1}{u+iv}$

$x + iy = \frac{u - iv}{u^2 + v^2}$

$x = \frac{u}{u^2+v^2} \quad y = \frac{-v}{x^2+y^2}$

$|z-1| = 1$

$|x + iy - 1| = 1$

$\left|\frac{u}{u^2+v^2} + \frac{-iv}{u^2+v^2} - 1\right| = 1$

$= \left|\frac{u}{u^2+v^2} - 1 - i\frac{v}{u^2+v^2}\right| = 1$

$|z-1| = \sqrt{\left(\frac{u}{u^2+v^2} - 1\right)^2 + \left(\frac{iv}{u^2+v^2}\right)^2} = 1 = \left(\sqrt{\frac{u^2}{(u^2+v^2)^2} - \frac{2u}{u^2+v^2} + 1 - \frac{v^2}{(u^2+v^2)^2}}\right)^2 = 1$

$= \frac{u^2}{(u^2+v^2)^2} - \frac{2u}{u^2+v^2} - \frac{v^2}{(u^2+v^2)^2} = 0$

$= \frac{u^2+v^2}{(u^2+v^2)^2} - \frac{2u}{u^2+v^2} = 0$

$= 1 - 2u = 0$

$2u = 1$

$u = 1/2$

21/4/22

M - 100.10.5.0
N - 100.10.5.[illegible]
P - 100.10.5.4

```
1111100 -
0000000
-------
0000100
```

```
1111100
0000110
-------
0000100
```

Error handling

- Error detection
  - Check during transmission of data
  - ~~Data + Data (copy)~~
- ~~Error correction~~

- data + data (copy)
- Single Parity check
  - add 1 extra bit along with data bit
  - applicable only for odd no of errors
- CRC
  - cyclic redundancy check
  - S | CRC gen | R
  - If CRC gen have n bit (n-1) bits add to data bit
  - then XOR with CRC gen
  - * Hardware approach
- Checksum

To find CRC bit

XOR CRC gen bit with data bit

eg:

```
1101 ) 10110110000   adding CRC gen bit  If CRC gen bit is 1101
       1101          first add 3 zero
       -----
       0110011000
        1101
        ----
       0001110000
           1101
           ----
        0011000
            1101
            ----
         0 001   → CRC bit.
```

Data sent : 1011011001

Reciever side also XOR CRC bit with data bits

If CRC is 000, data recieved is right.

If CRC gen is in polynomial form x^3+x+1

$1.x^3+0.x^2+1.x^1+1.x^0$

CRC → 1011

22/4/22

Checksum

software approach

for 8 bit check sum, find decimal equivalent of each octet and add. Checksum = - (sum) eg: -13

It will send to reciever, while receiver adding the data bit and checksum, if it is zero then there is no

eg:

00000011 | 00000001 | 00000010 | 00000111

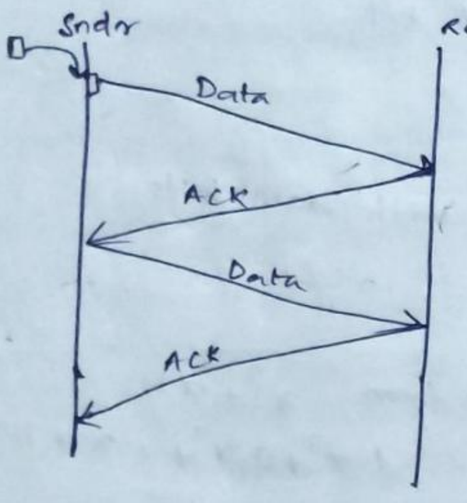
3 1 2 7

7+3+2+1 = 13

Checksum = −13 → receiver → 3+1+2+7 + −13 = 0 ✓

Flow Control

- stop & wait protocol



- Time to put the data packet in to transmission link is transmission delay.

- time for one bit to travel from snd side to receiver end is called propagation delay.

- Queuing delay, processing delay.

Total transmission time = Transimission delay + prop delay from sender to Rec + prop delay from rec to sndr

$= T_t + T_p + T_p$

$= T_t + 2T_p$

Efficiency = Usefultime / Total cycle time

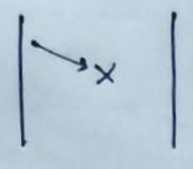
$$E = \frac{T_t}{T_t + 2T_p}$$

1) $T_t = 1ms \quad T_p = 1ms$

$$\eta = \frac{1}{1+2} = \frac{1}{3} = 0.33 = 30\%$$

problems occur in stop & wait protocol

I. 1. Lost Data 2. Lost acknowledgement



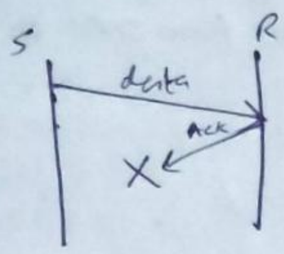
Receiver didn't get the data
snder didn't get akk

Solution

→ Time out Timer
- If sndr didn't get ack it resends the packet

Stop & Wait + Time Out Timer = Stop and wait ARQ
Automatically Repeat

2) Lost Acknowledgement



Sndr didn't receive the ack line

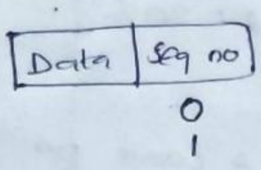
After Time out Timer sndr resend data packet

↳ results Duplicate Packet of data

solution

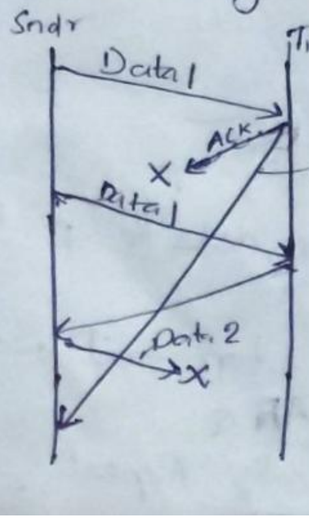
- Sequence Number

Stop + wait + Time out Timer + Seq number



use only 0 or 1 to reduce the no of bits of Seq no.

3) Acknowledgment delayed



Sndr thinks it is ack line of Data 2

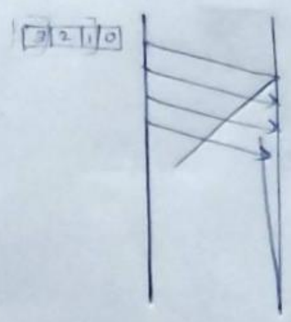
This is missing packet problem.

solution

Sequence number to ack line

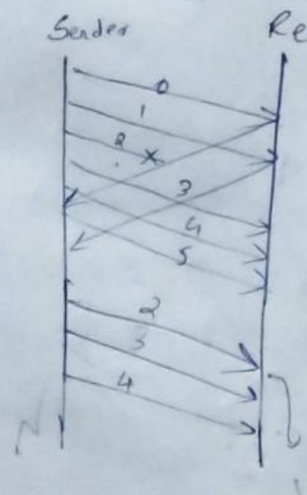
Ack no = seq no + 1

5|5|22 Sliding window protocol — GobackN / selective



Not waiting for ack.

Go Back N



* Sndr window size is N
* Receiver window size is 1

In GBN proto, Receiver doesn't accept another data # until the expected data is received.

Resends 2 bcs absence of ack of 2

At sender, ~~w~~ sliding window only move when appropriate ack received.

~~size of~~ GB4 - size of sender window is 4

? In GB4 from the 10 packets to transmitted if every 6th packet is lost. How many transn is req?

1 2 3 4 5 6 7 8 9 10

↑ lost

~~1+1+4 = 14~~

1 2 3 4
2 3 4 5
3 4 5 6
4 5 6 7
5 6 7 8
6 7 8 9
6 7 8 9 6 7 8 9 10
resend
lost
8 9 10 8 9 10
resend

1 2 3 4 5 6 7 8 9 6 7 8 9 10 8 9 10

Total = 17

? GB3

1 2 3 4 5 6 7 8 6 7 8 9 10 9 10 = 15

? GB 5

1 2 3 4 5
2 3 4 5 6
3 4 5 6 7
4 5 6 7 8
5 6 7 8 9
6 7 8 9 10
6 7 8 9 10 6 7 8 9 10
7 8 9 10 7 8 9 10
~~7 8 9~~ 9 10
1 2 3 4 5 6 7 8 9 10 6 7 8 9 10
↑
1 2 3 4 5 6 7 8 9 10 9 10 = 21

~~Total = 15~~

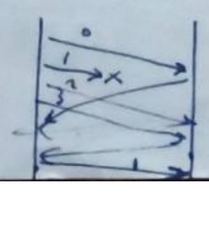
12/5/22

Selective Repeat

Sndr window size & sender window size is same

$W_S = W_R$ 4 [windows are implementing as linked list]

selectively send the lost ~~data~~ packet only. Not all packet



0 2 3
0 1 2 3

out of order - it will sort
sorting is not easy
If 1 pckt is lost had to search entire LL ie Time consumin

In SR 10 packets to be

1 2 3 4 5 6 7 8 9 10

lost ↑

5 6 7 8 9 10

lost ↑

9 10

÷12

Framing

The data link layer needs to pack bits into frames so that each frame is distinguishable.

packing of bits - frame

SFD - Start Frame Delimiter ← | | 10100 | | → EFD

EFD - End Frame Delimiter

→ remainder for system, informs the packet is coming.

Every system check destination address is its or not

SFD added to begining of frame, show that data packet has arrived and they have to check the destination address that is after the SFD.

Receiver should know the sending packet is ending or not. To know that

Frame

- Fixed
  - when size is fixed fill the packet & snd even filling is not sufficient snd with dummy bits
- Variable
  - END Delimiter
    - Character Stuffing
      - use charac to indicate packet is finished/end
    - Bit Stuffing
      - To show es: $.... /o$ cancels null and take data
    - Length
      - include a length field.
      - Problm:- If length field got corrupted during transmission, data reading will not complete.

bit stuffing

01111 — END when this pattern occurs

0111 - add 0 to second last pos

01101

1000 - add 1 to second last pos

10010

? In a data link protocol, the fram delimiter flag is given by 0111. Assuming that bit stuffing is employed, the transmitter sends the data sequence 01110110 as

~~01110011~~ 0110101100

? 10001 1000011000010

1000101100010

? 0111111 01111001111110

011110001111010

23/5/22 ISO - OSI Layer [open system Interconnection]

P1 ←IPC→ P2 → same host

P1 \ Network / P2 ⇒ Diff host

ISO - OSI - 7 layers

L 7 - Application
L 6 - Presentation
L 5 - session
} user application

L 4 - Transport
L 3 - Network layer
L 2 - Data link layer
L 1 - Physical layer
} communications technology

Application layer

→ level which applications access network services
→ user
→

Presentation

→ rep of transmitted data
  → uniform standard format
→ Provide services for secure efficient data transmission
  eg: data encryption & data compression

Session

→ a application
→ dialog control
→ perform token management & synchronization

Transport layer

→ Manages transmission packets
  divides in to small packets & transmit
→ Handles error · recognition & recovery

Network layer

→ Managing logical addressing like IP with in the subnet
→ Routing
  * based on static tables
  * determine start
  *

Data link layer

→ framing
→ flow control

physical layer

→ Electronic part of transmission
→ using ~~form~~ current (light, object) for transm
→ Using cables

Transmission mode of physical layer

- Simplex / Duplex

→ Simplex

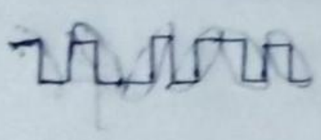
⇄ Half duplex

⟷ full duplex

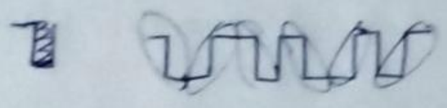
→ How we can encode the data (in of physical layer)

Manchester Encoding

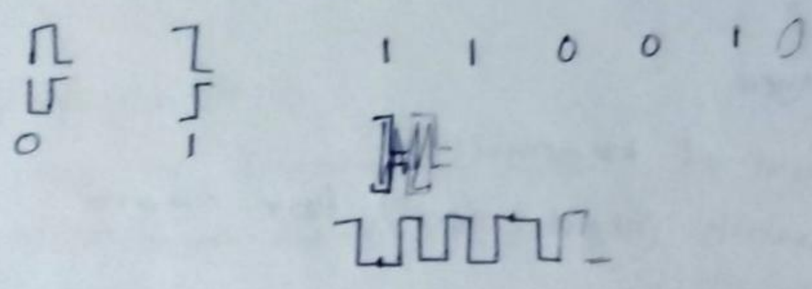
110011 rep (1) as ⌝
rep (0) as ⌟



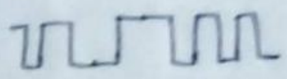
1 0 1 1 0 0



Differential Manchest Encoding



1 0 1 1 0 0



TCP/IP protocol suite

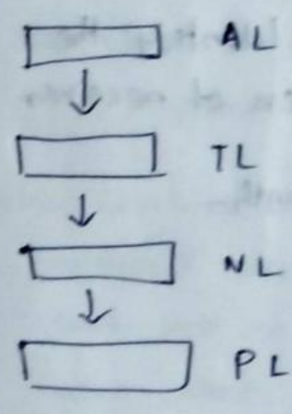
only 4 layer

1) Host to network - ~~SMTP, FTP, HTTP, DNS, SNMP~~
2) Network - IP
3) Transport - SCTP, TCP, UDP
4) Application - SMTP, FTP, HTTP, DNS, SNMP,

Datalink layer - Node to node delivery

Network - responsible to transform from host to host (1 comp → 1 comp)

Transport - moving packet from process to process.

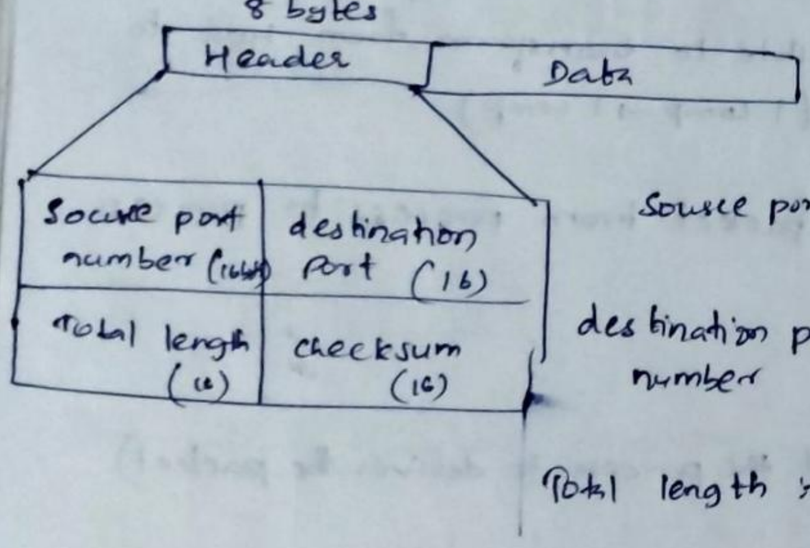


Process - to process communication

Two types

1) UDP (User datagram protocol)

- connectionless protocol
- receiver does not snd ack
- packet we called as datagram
- Transfer data is high speed
- no good accuracy & reliability
- not necessary to reach all data to receives side



Source port = Identify the process of sender

destination port = Identify the number process of receiver

Total length = IP length -

Advantage

- broadcast multicast transmission
- faster than TCP
- use small size of header
- takes less memory than other protocol

disadvantage

- It is an unreliable protocol.

Application

- DNS
- S
- gaming

TCP

- provides full transport layer services to application.
- connection - oriented

for creating connection, TCP generate a virtual circuit b/w sndr & reciver

features

- Reliable :- Assign seq no & get ack, a retransmission also takes place.
- flow control :- Indicates no of bytes it can receive without overflowing its internal buffer.
  last Ack no indicates highest seq no.
  also called window mechanism.

TCP header

header size - 20 bytes

Source port no | Destination port add

Seq no (32 bits)

Ack no (32 bits)

HLEN (header length)	Reserved	URG	ACK	PSH	RST	SYN	FIN	Window size
4 bits	6 bits							16 bits

Checksum | urgent pointer (16 bits)

options & padding

Source port address :- define address of application program of sousce comp

Destination port address :- " of dest computer

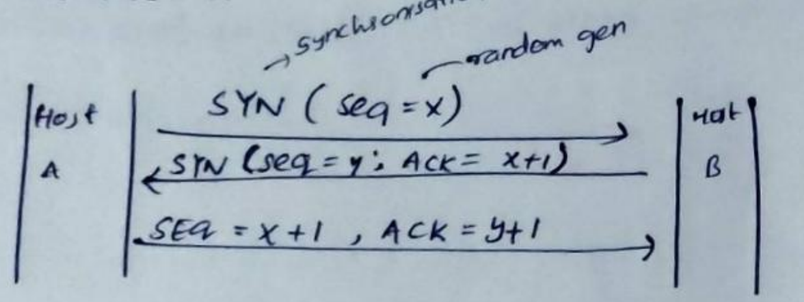
Ack nor :- seq no :-

TCP - connection Establishment

- three-way handshake mechanism

~~- to make transp~~

Client & service agree up on a seq no & ~~matte~~ transmission.



* full duplex
* Expecting (x+1)

3-way handshake

Header file

Port A	Port B
90	
SYN	Window size = 12000
Max win size is 1200	

client

For one packet it'll take = $\frac{120000}{1200}$ = 10

so another header file is for server side.

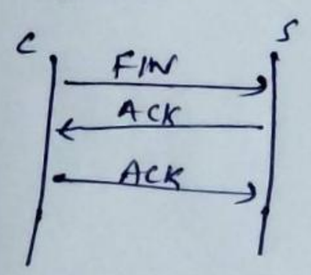
Connection Termination Protocol

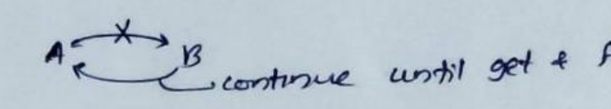
→ If server want to finish con, it snd fin packet (release me)

→ Here client can't snd any more after 2 steps

→ terminate seperately [full duplex]

3 step com





Here server can snd until fin

1) Active close = side which first fin req (initiating the termination)

2) Passive close

27/5/22

Retransmission

Sndr discover TCP segment is lost by either TOT expire on 3-dup duplicate ack retransmission

If a pckt is snd and it is not reach in rcvr side. After TOT it will retransmit same segment.

Snd In the case sndr doesn't receive ack line, retransmit same seg and get ack.

Another way is,

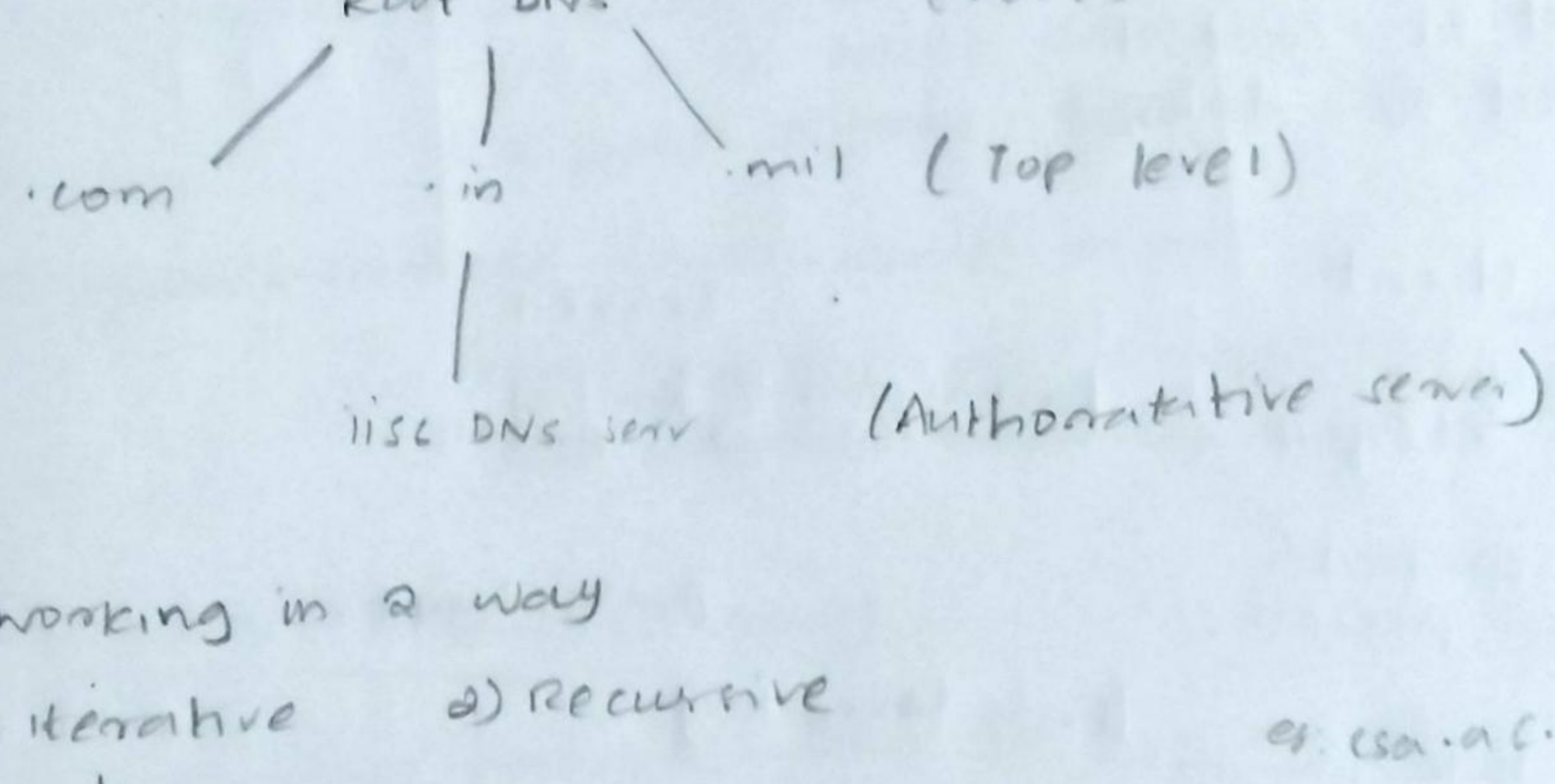
1st seg ⟶

⟵ ack seg 1

DNS

- domain name → IP address
- uses UDP at transport level
- connectionless protocol

1) Generic Domains (.com, .gov, .org)
2) Country "
3) .



working in 2 way

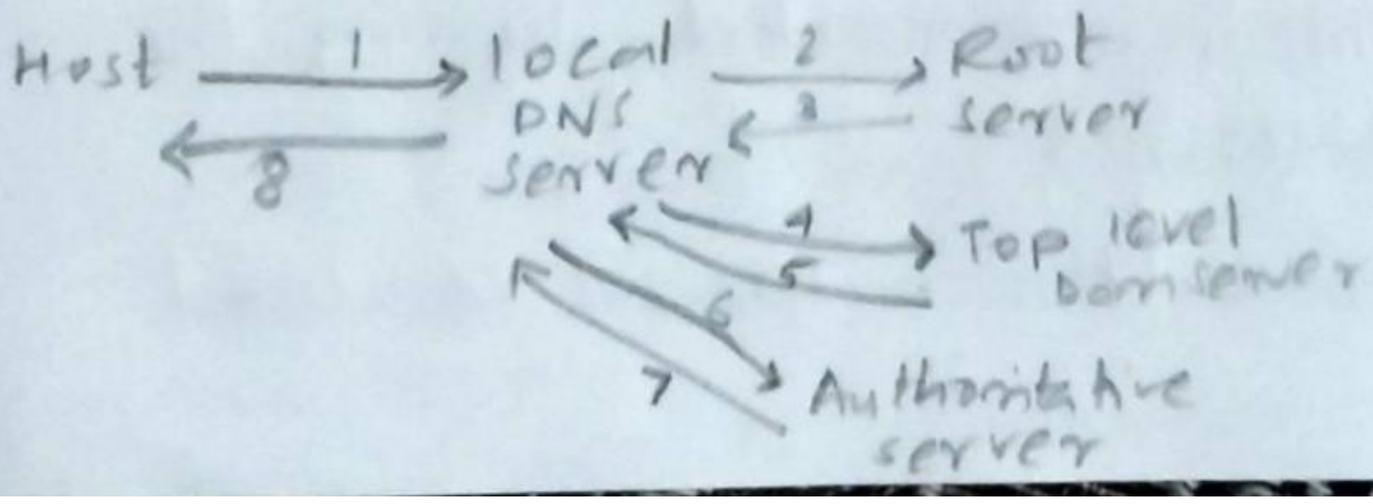
1) Iterative
2) Recursive

↓

Host ask IP (DNS ask root server)

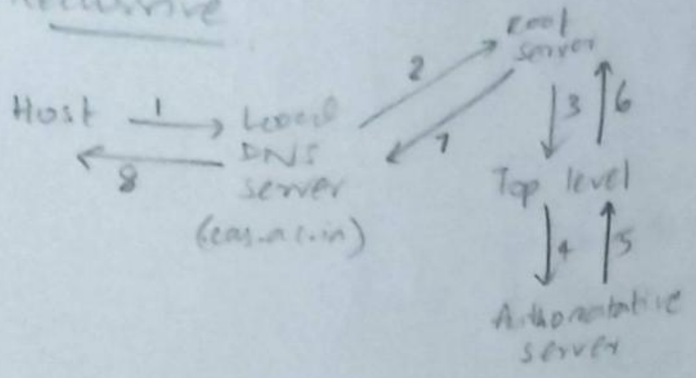
eg: .ac.in

eg: Root give .in
Top level give .ac
Author give .iisc



27

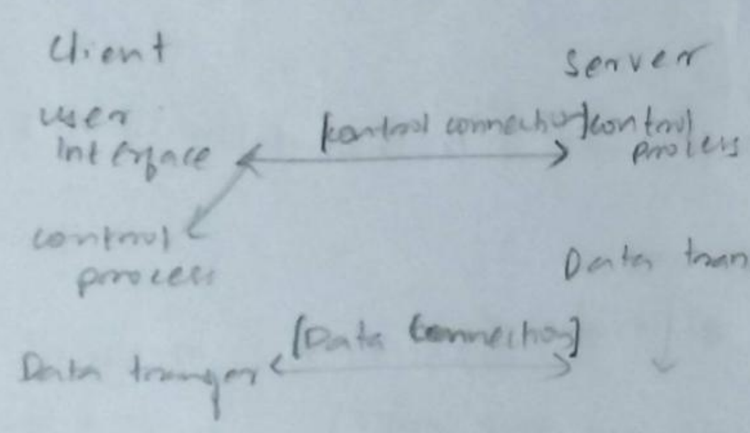
2) Recursive



header

File Transfer Protocol (FTP)

- using for transfer file
- connection oriented prot
- a connection — data transfer
  — control information
- Port 21 - control
  Port 20 - data



- control connection remains connected during the entire interactive FTP session
- Each time ~~a~~ data connection is opened & closed multiple times.
- control connection once open, terminate after entire process
- data connection
- control connection in the form of commands
  eg. retrive, store
  (RETR) (STOR)
- client node

File-types of FTP

- ASCII

Transmission modes of FTP

- stream mode [continuous stream of bytes]
- Block mode [3-byte header
  1st bit is block descriptor
  2 byte destroy size of block]
- compression mode [run-length encoding]
  repeating dat are compressed and snd whenever needed

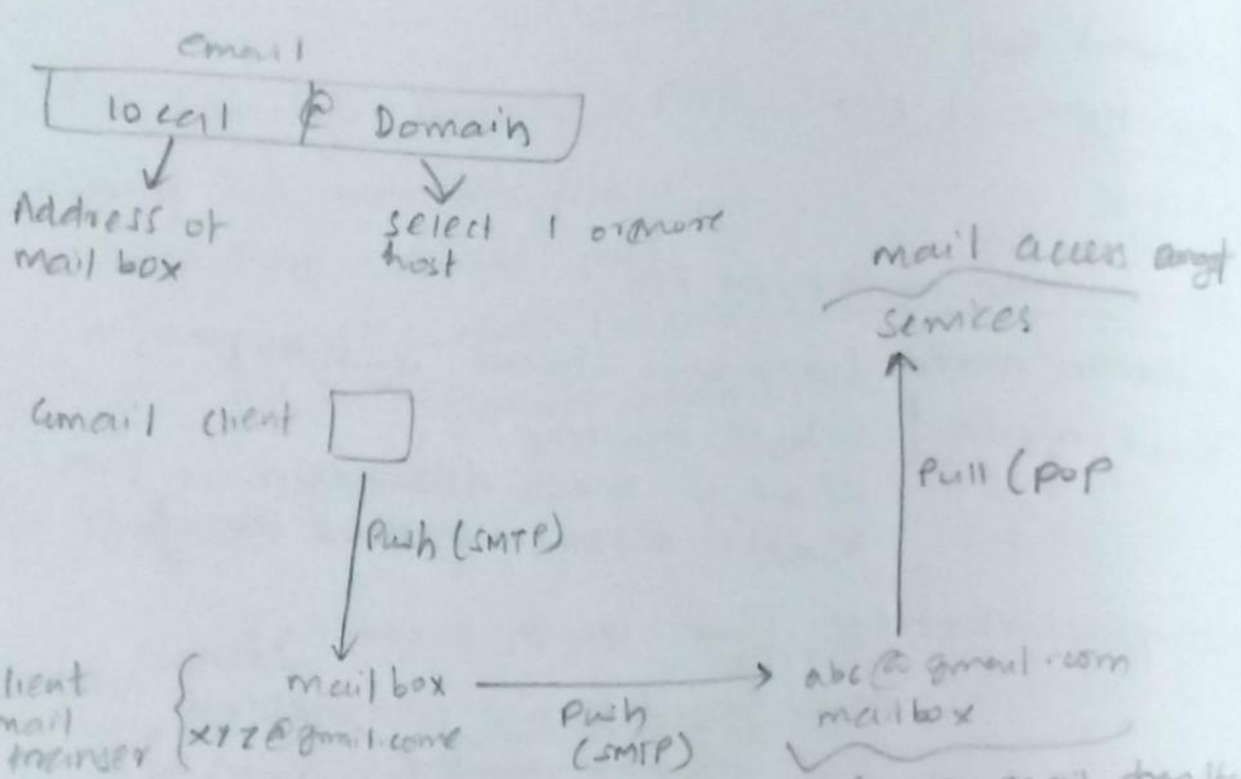
Electronic Mail (E.mail)

- for all other protocol systems must be online
- An offline method is e-mail.
- 2 types of protocol for Email

1) SMTP - simple Mail Transfer Protocol
   - application layer protocol - out-bound protocol
   - uses TCP - connection oriented prot - push
   - port number 25

2) Pop (Post office Protocol)

- uses tcp at transport layer
- port number 110
- connection oriented
- in-brand protocol



Message Access Agent

1) POP3 2) IMAP4 (Internet Mail Access protocol)

POP3

- uses port 110 (username, password → -doesn't allow the user to partially check the contents of mail before downloading
- IMAP4
- similar to pop3
- more powerful & complex
- extension
  - User can check email - pair to downloading
  - can create, delete or rename mailboxes