Data Communication & Networking

21.04.2024

* Telecommunication
* Data communication
  - Sender
  - Receiver
  - Message
  - Medium
  - Protocol

  5 components

Protocol
- Syntex (কত bit send/receive possible)
- Semantics (H/T এ Data-র type define করে)
- Timing (কখন কোন data packet pass হচ্ছে)

data packet
(16 bit)

Data flow :

* Simplex : → one way communication
  → keyboard, monitor, radio

* half-duplex : → two-directional
  → one way communication at a definite time

* Full duplex → telephone, internet
  → direction of data at all time

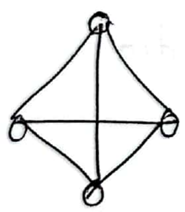
Network : → communication link among set of devices
→ for exchanging data
→ Criteria (throughput কত, perf কেমন, reliability কেমন, secured নাকি, delay ↓ better ↑)

Types of connections :

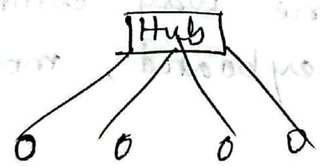
* Point to point (one → one)
* Multipoint (one → different stations)

• unicast, multicast, broadcast.

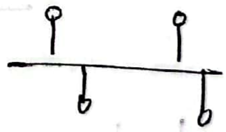
Topology :



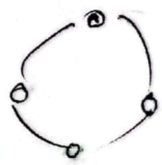
→ Mesh
→ $n(n-1)$ links
or $\frac{n(n-1)}{2}$ links
→ cost ↑
→ wire ↑
→ complexity ↑
→ all connected
→ secured



→ Star
→ If hub X, system crashes
→ security ↓

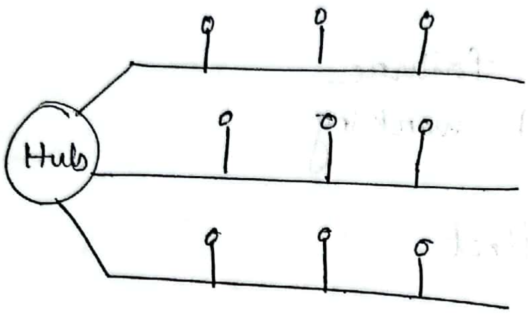


→ bus



→ Ring
→ If one station is destroyed, then system crashes.

Hybrid :



→ star with three bus networks.

* geographical based → 1) LAN (Ex : network in an office)
2) MAN
3) WAN

* Protocols & Standards

Practice 1 22.04.2024

If one connection fails.

* 5 device in mech ⟶ no problem

But if
→ multiple link failure
→ devices aren't working

* Star ⟶ no affect

But if
→ central hub is n't working

* Bus ⟶ if backbone is secured then no problem.

* Ring ⟶ system craches

$\frac{n(n-1)}{2}$ → bidirectional link
$n(n-1)$ → unidirectional "
(n-1) ports

} in mesh

warehouse + main office + sales office in another city.

each other ⟶ LAN (within 12 meter range)

main office, warehouse, remote sales ⟶ WAN (✓)

remote sales office wants access to main office
↳ WAN / MAN
↳ (Internet)

NETWORK LAYER

node $\xrightarrow{\text{data packet}}$ node

packets are sent using some protocols or procedures.

*** $\boxed{\text{7 layer}}$:

All People Seem To Need DATA Processing

- All — Application
- People — Presentation
- Seem — Session
- To — Transport
- Need — Network
- DATA — Data link
- Processing — Physical

higher $\xrightarrow{\text{layers}}$ lower

OSI Model

layer → decision নিতে help করে কখন কিভাবে data packet sender to receiver end এ যাবে।

28.4.24

Tasks involved in sending letters

→ higher layer

→ middle layer

→ lower layer

Note :

1) ISO is an org.

2) OSI is model.

7 layers (OSI model)

7 — Application
6 — Presentation
5 — Session
4 — Transport

3 — Network
2 — Data link
1 — Physical

$\left.\begin{array}{l}\text{7 — Application}\\ \text{6 — Presentation}\\ \text{5 — Session}\end{array}\right\}$ higher

4 — Transport → middle

$\left.\begin{array}{l}\text{3 — Network}\\ \text{2 — Data link}\\ \text{1 — Physical}\end{array}\right\}$ lower

Tail add হয়

peer to peer (Point to Point) → 4 to 7th layer

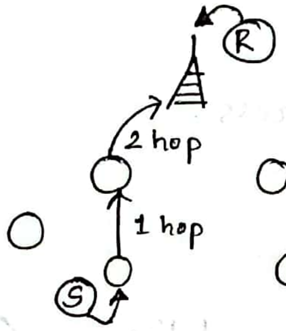
Multipoint → 1st to 3rd layer

Transmission কিভাবে হচ্ছে তা determine হয় এই layer-এ। → Topology

Physical layer :

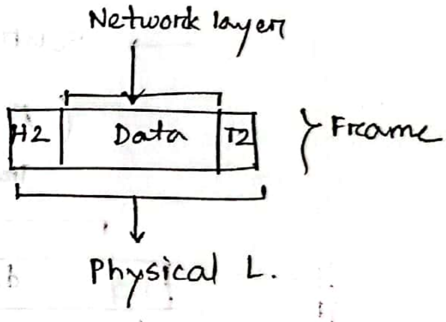
- → bit by bit transfer — → signal dig. or analog.
- → transport medium use করে (half duplex / full duplex / simple) — → Topology determination
- → clock synchronization

This layer is responsible for movements of individual bits from one hop to the next.



S → R
↳ physical layer এর মাধ্যমে pass হয়।

Data Link Layer :



- → Frame আকারে যায় (Framing)
  - data কে কয়েকটা bit এর packet আকারে convert করে (8 bit/ 16 bit)
- → Reliability → T2 is ~~using~~ to being used as error detector. (error detection & error control)
  - ↳ H2 is address

Transport L এর ও কাজ

- → hardware/mac address (injected in network interface card)
  - ↳ physical address that doesn't change
- → Fragmentation (8/16 bit করে packet (frame) transfer)
- → ~~clock synchronization~~ Flow control + access control
- → hop to hop delivery

raw bit transfer

Peer to peer → Data link layer

A → B

└→ | A | B | data | T |

B → E

└→ | B | E | DATA | T |

↓

These are H/W address.

} hop to hop address change হবে।

<u>Network layer</u> :

→ source to destination delivery (data packet delivery)

(A to F কিভাবে যাবো)

Transport L.

| H3 | data | Packet)

↓

logical address (IP address)

data Link L.

→ root determine (routing → by which algorithm)

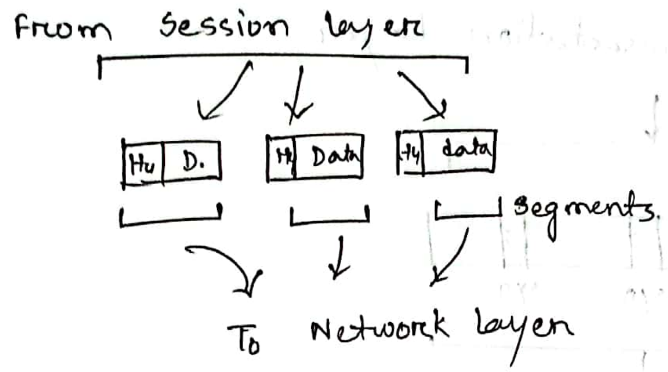
(routing & forwarding)

5 টা service (কোনটা কোন layer এর কাজ)
layer এর কাজ

The network L. is responsible for the delivery of individual packets from source host to the destination host.

Transport Layer :

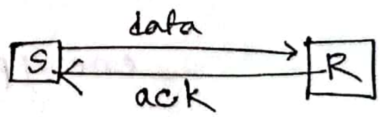
→ service point addressing (Port address) → header define করে
→ Process to process delivery



→ Segmentation & Reassemble.
→ connection control (mobile - এ msg sending)
  → connection - oriented (TCP, UDP)
  → " -less

→ Flow control

→ Error control



↳ সঠিকভাবে data recieve করলে acknowledgement signal দেয়

error থাকলে data-তে,

1) NACK signal দেয়
2) Retransmission of data

বারবার transmit → transmission time বেশি।

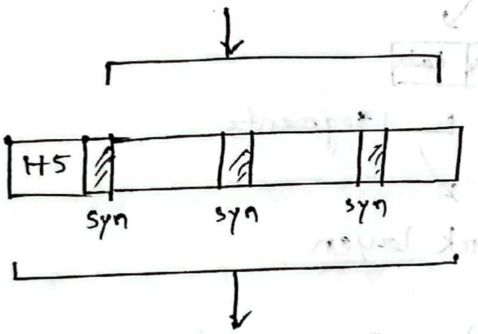
Session Layer :

→ dialogue control

→ (half duplex নাকি full duplex) - communication কিভাবে হবে তা determine

→ Synchronization

from presentation Layer



To transport layer

Presentation Layer :

→ syntax, semantic

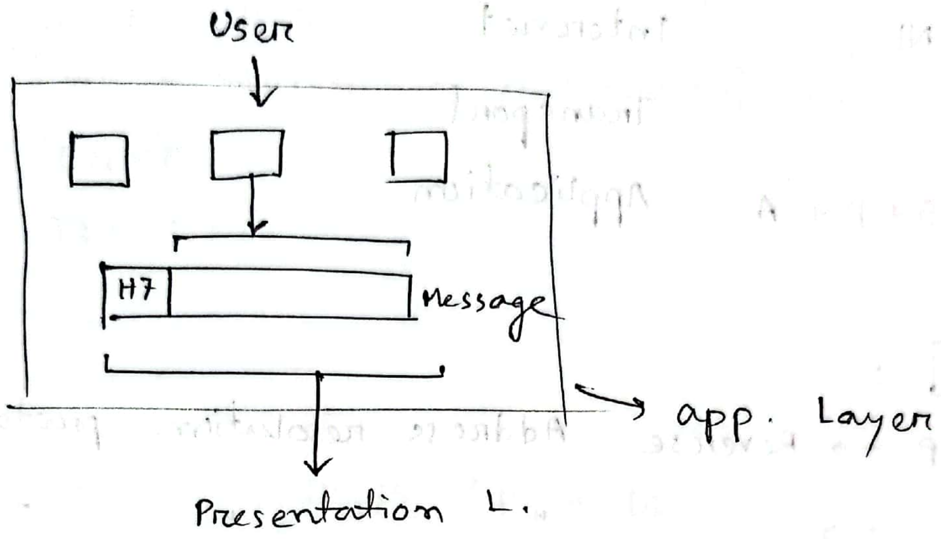
(কত bit, কিভাবে audio send, modulation কেমন)

(format define, compress (video) করা লাগবে কিনা, encryption)

→ translation, compression, encryption

Application Layer :

Specific address



29.4.24

TCP/IP Model :

PL + DL   Host to Network — Topology + hop to hop deliv...

NL   Internet

   Transport

S + P + A   Application

Internet :

Note : Detail লাগবে না
*** Name of the protocols

RARP → Reverse Address resolution protocol

ARP → " " "

↳ IP address থেকে mac address খুঁজে বের করে।

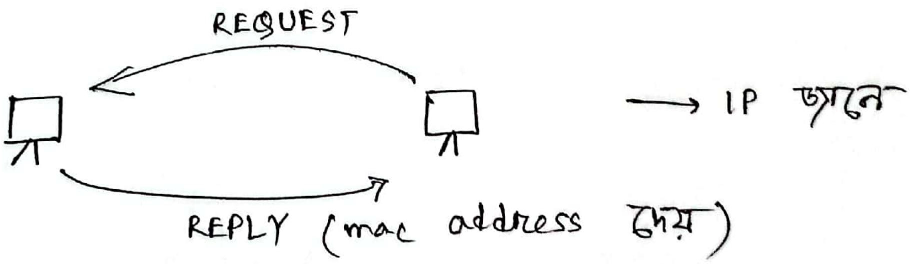


Fig : ARP

Transport

TCP — Transfer Control Protocol (connection oriented)
↳ data com. এর আগে connection establish হবে।

UDP — connection less

(৫) কোনটা কোন layer এর protocol..

Application :

SMTP
FTP - email
HTTP - web
DNS - server (IP translation)
SNMP
TELNET

Addressing

DL • Physical address (PL + DL)

Network interface card → injected address

NL • Logical address (IP address)

TL • Port address

AL • Specific address (Ex: email, url)

2.19

LAN → sender to receiver direct pass possible.

একই LAN → DL layer দিয়েই হবে।
NL লাগবে না।

2.20

sample physical address → 6 byte (12 hexadec. digits)

2 LAN are connected ↔ via router.
(NL এর device)

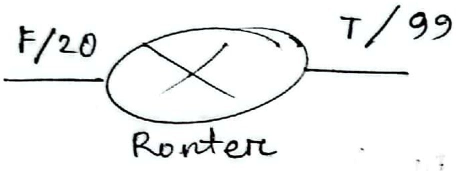
A/10
↳ Physical address
↳ logical address

* router (NL)
* switch (DL layer)

A/10 (Sender)

physical address

logical add/mac add



Note :

1) NL → source A, destination P define করে

A	P	Data

2) DL L → hop A/10 to hop F/20

20	10	A	P	Data	T2

3) প্রতিটা hop এ physical addresses change হয়

4) DL is hop to hop delivery
NL is source to destination delivery.

Data packet → upper layer / application layer এ create হয়।

Data

Sent to NL.
source A & destination P

A	P	Data

NL

- hop to hop (A/10 to F/20)

20	10	A	P	Data

-

2.2.1

* logical & port address unchanged
* physical addresses change from hop to hop.

a, j → Port address (16 bit)

A, P → logical "

(Process to process delivery)

CT-1

(3/4 questions)

5/5/24

7.7.2024

Chapter 10

ERROR DETECTION & CORRECTION

$\boxed{S} \xrightarrow{\text{message}} \boxed{R}$

একটি or একাধিক bit change → message being corrupted while transmission

single bit error → one bit of data has changed.

burst error → 2 or more bit of data have changed

└→ maximum time এ burst error -ই occur করে।

Affected bit = data rate * noise duration

let, data rate = 1 kbps

noise duration = $\frac{1}{100}$ (↓)

affected bit = $1000 \times \frac{1}{100}$ = 10 bits. (↑)

↓

burst error

- To detect or correct error → send extra bits with data (DL layer এর trailer).

Sender → generator

Receiver → checker

- block code → modulo - 2

X-OR → Two bit same → 0

" " diff → 1

Block coding :

r → redundant bits

Data + r → codeword
(k bit) (length n)

Examples → home practice

$\boxed{10.2}$

data word → 2 bit = k   n = k + r
code " → 3 bit = n   so, r = 3 − 2 = 1

00 → 000
01 → 011
10 → 101
11 → 110
↓
redundant bit

even parity

Parity bit :
→ odd (number of 1 is odd numbered)
→ even (" " 1 " even "
↳ normally this is used.
→ Single bit error detect করতে পারে।

Ex : Sender → 0101
Receiver → 0111 → error → but cannot correct
but what if, receiver → 1111 → cannot detect 2 bit error

s → syndrome

Hamming distance :
number of

000, 011 $\xrightarrow{\text{hamming dis.}}$ $000 \oplus 011 = 011$ → two 1's

H.D = 2
↓
$d_{min} = s + 1$

So, minimum 1 টা error can be detected.

Table 10.3 → even parity

X-OR $a_1 \oplus a_2 \oplus a_3 \oplus a_4$ → for even parity

odd → $\overline{a_1 \oplus a_2 \oplus a_3 \oplus a_4}$

Two dimensional parity check
↳ burst error check ; but has some limitation

$\boxed{10.4}$

7	6	5	4	3	2	1
D_7	D_6	D_5	P_4 (2^2)	D_3	P_2 (2^1)	P_1 (2^0)

data = 4
r = 3
code = 7
PB = r = 3
$2^0 = 1$
$2^1 = 2$
$2^2 = 4$

CamScanner

P_1 define করতে $\longrightarrow$ D_3 D_5 D_7

P_2 " " $\longrightarrow$ D_3 D_6 D_7

P_4 ~~ooo~~ " " $\longrightarrow$ D_5 D_6 D_7

D7 D6 D5 D3
1011

D7	D6	D5	P4	D3	P2	P1
1	0	1	0	1	0	1

P4: 1⊕0⊕1 = 0

P1: 1⊕1⊕1 = 1

P2: 1⊕0⊕1 = 0

0111

MSB or D7

D7	D6	D5	P4	D3	P2	P1
0	1	1	0	1	0	0

Q) If the 7-bit hamming code word received by a receiver is 1011011. Assuming the even parity, state whether the receiver codeword is correct or wrong. If wrong locate the bit having error.

D7	D6	D5	P4	D3	P2	P1
1	0	1	1	0	1	1

error হলে or contradict করলে $P_1 = 1$

P1 = 0 $\longrightarrow$ but আছে 1 (error) P1 = 1

P2 = 1 $\longrightarrow$ no error $\rightarrow$ P2 = 0

P4 = 0 $\longrightarrow$ but আছে 1 (error) $\rightarrow$ P4 = 1

To find the corrupted position

P4	P2	P1
1	0	1

$\longrightarrow$ 5th position এ error

$r = 3 \longrightarrow$ upto 2 bits can be detected and 1 bit can be corrected.

correct codeward is 1001011

Ex 10.13 $\longrightarrow$ Do yourself

exercise from book.

CYCLIC CODE :

CRC $\longrightarrow$ cyclic redundancy code

sender, receiver $\longrightarrow$ both use a divisor $(d_3 d_2 d_1 d_0)$

* this code can only detect ; cannot correct.

Q) Find the CRC for the data blocks 100100 with the divisor 1101 ?

Step 1 : Find the length of the divisor 'L'

Step 2 : Append (L-1) bits to the original message

Step 3 : Perform binary division operation

Step 4 : remainder = CRC

L = 4   (1101 → length = 4)

```
        original msg   append (4-1) = 3 bits
1101 |  100100         000
        1101
        ----------------
         1000
         1101
        ----------------
          1010
          1101
        ----------------
          ~~0~~1110
           1101
        ----------------
           00110
            0000
        ----------------
            ~~0~~1100
             1101
        ----------------
              001  → remainder
```

CRC = 001

Q) Find the CRC for 111001 0101 with the divisor $x^3 + x^2 + 1$.

Note :

Let, expr. is $x^6 + x^5 + x + 1$

$$x^6 \quad x^5 \quad x^4 \quad x^3 \quad x^2 \quad x^1 \quad x^0$$

$$1\cdot x^6 + 1\cdot x^5 + 0\cdot x^4 + 0\cdot x^3 + 0\cdot x^2 + 1\cdot x + 1\cdot 1$$

1 1 0 0 0 1 1

→ divisor

$x^3 + x^2 + 1 \longrightarrow 1101$

```
           1010000110
1101 | 1110010101000
       1101
       ----
        0110
        0000
        ----
         1101
         1101
         ----
          0000
          0000
          ----
           0001
           0000
           ----
            0010
            0000
            ----
             0101
             0000
             ----
              1010
              1101
              ----
               1110
               1101
               ----
                0110
                0000
                ----
                 110
```

HOME TASK :

Suppose we want to transmit the message 11001001 and protect it from errors using the CRC polynomial x^3+1. Use division to determine the message that should be transmitted.

Corrupt the leftmost third bit of the transmitted message and show that the error is detected by the receiver by using CRC.

11101001

10.18 → Not for exam

R : 0 → no error

→ error

8 . 7 . 2024

Sender

$x^3+1 \longrightarrow 1001$ — 101

```
1001 ) 11001001000
       1001
       ----
        1011
        1001
        ----
         0100
         0000
         ----
          1000
          1001
          ----
           0011
           0000
           ----
            0110
            0000
            ----
             1100
             1001
             ----
              1010
              1001
              ----
               011  → CRC
```

Receiver end

1 1 0 0 1 0 0 1

Re: $\boxed{1\ 1\ 1\ 0\ 1\ 0\ 0\ 1}$

Receiver এ CRC append হয়

codeword = dataword + remainder (CRC)

```
1001 | 1110 1001 011
       1001
       ----
        1111
        1001
        ----
         1100
         1001
         ----
          1010
          1001
          ----
           0111
           0000
           ----
            1110
            1001
            ----
             1111
             1001
             ----
              1101
              1001
              ----
               100
```

dataword discarded.

divisor → generator polynomial

* $S(x) \neq 0$ → one or more bit corrupted
  $S(x) = 0$ → 1. No bit corrupted
  2. Some bits are corrupted, but decoder failed to detect them.

* Single bit error detect
  ↳ x^0 is 1
  → more than one term
  } Ex : $1+x$

$1+x$ cannot detect two bits error.

* generator x^3 → 3 bit এর বেশি error ধরতে পারবে না।

* 10 bit error থাকলে → x^{10} term থাকতে হবে।

*

Checksum

- → error checking in different protocols
- → sum সাধারণ
- → remainder 0 → no error in receiver
- → sum → bit number বেশি হলে
  ↓
  1's complement

Sender

7
11
12
0
6
0 ← let checksum = 0

SUM → 36 → 100100 (6 bit)

wrapping:

```
  100100
  ↳   10
  ------
    0110  (6)   Wrapped Sum
1's comp
    1001  (9)   Checksum
```

Receiver :

7
11
12
0
6
9 ← checksum

45

```
 101101
     10
 ------
   1111  (15)
1's comp
   0000  (0) → error-free
```

Note :

→ single error detect possible (always)

→ sum same + error ✓

↳ cannot detect error

14.7.2024

Chapter 12
Multiple Access

→ protocols needed for managing access as there are multiple users.

→
DL layer

Data link control
Multiple-access resolution

→ multiple access protocol

1) Random access Protocol
   ↳ যে যখন ইচ্ছা data transfer করে
   CSMA → internet / normal network এ
   CSMA/CD → ethernet
   CSMA/CA → wireless environment এর জন্য
2) controlled access protocol (central controller থাকে)
3) channelization protocol (for small network, not for large " system, in that case we need distributed ~~proto.~~ communication system)

distributed system
time constraint ×
resource " ×
& good system

Random access :

→ central node নেই কোনো ; যে decision দিবে
→ যার যখন data packet আসবে সে তখন transfer করবে।

- **ALOHA** : 12.3 → Pure ALOHA
  Frame 1.1 → pass হবে data packet
  Frame 1.2, 2.1, 3.1, 4.1 → collision / overlap
  ↓
  data packet won't transfer
  (sender will resend frames)

① Pure ALOHA
② Slotted
collision

$T_p = \frac{\text{Length}}{\text{Rate}}$ T_{fr} = propagation time

Transmission time $= \frac{d}{s}$

Fig 12.4 ⟶ Procedure of ALOHA

* Start → K=0 — station has a frame to send

No. of attempts

K_{max} = 15 / 16 (channel এ যদি taint থাকে তাহলে যাতে ∞ times resend করতে না হয়)

max attempt of transmission

* Kmax times number of retransmission

Data

S → R

Ack (T_p)

↳ data successfully পেয়ে গেলে

$2 \times T_p$ = wait time

$T_p = T_{fr}$ — avg transmission time for a frame

R ⟶ backup window ⟶ 0 to $(2^k - 1)$

K

$2^0 = 1$ ⟶ R between 0

$2^1 = 2$ ⟶ R " 0, 1,

$2^2 = 4$ ⟶ R " 0, 1, 2, 3

wait T_B time, $T_B = R \times T_p$ or $R \times T_{fr}$

latency ↓ good network perf ↑

a little improvement :

frame এর transmission time (let 0 to 10 sec) এর মধ্যে অন্য কেউ frame send যদি না করে ।

↳ CSMA

$\boxed{12.1}$

wireless stations $\longrightarrow$ distance = 600 km

speed = 3×10^8 m/s

$$T_p = \frac{\text{distance}}{\text{p. speed}} = \frac{600 \times 10^3}{3 \times 10^8} = 2 \text{ ms}$$

For $K = 1 \longrightarrow R = 0, 1.$ $\;\hookrightarrow x$

So, $R = 1$ এর জন্য, T_B = back off time

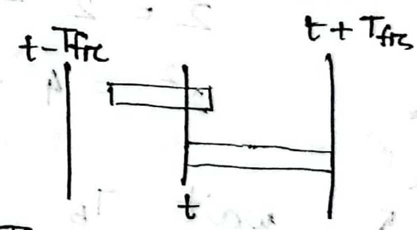
$= 1 \times 2\text{ ms} = 2\text{ ms}$

$K = 2 \longrightarrow R = 0, 1, 2, 3$

$T_B = 0 \quad 2 \quad 4 \quad 6$ ms

$K = 3 \longrightarrow R = 0, 1, 2, 3, 4, 5, 6, 7$

$(R \times T_p)$ $T_B = 0 \quad 2 \quad 4 \quad 6 \quad 8 \quad 10 \quad 12 \quad 14$



- vulnerable time = $2 \times T_{fr}$

$\longrightarrow$ যত কম হয় তত ভালো

$\boxed{\text{Note}}$ throughput for pure ALOHA, avg transmission time

* $S = G \times e^{-2G}$

* $S_{max} = 0.184 \longleftarrow (G = \frac{1}{2})$

$T_{fr} = \frac{L}{R}$

vulnerable time $= 2 \times T_{fr}$

$\boxed{12.2}$

200 bits (frame)

200 kbps

T_{fr}, time $= \dfrac{\cancel{200} \text{ bits}}{\cancel{200} \times 10^3 \text{ bit/sec}} = \dfrac{L}{R}$

$= 1$ ms $\longrightarrow$ avg transmission time

vulnerable time $= 2 \times 1$ ms $= 2$ ms

$\boxed{12.3}$

frame transmission time $= \dfrac{\text{bit}}{\text{speed}} = \dfrac{200}{200 \times 10^3}$

$= 1$ ms

a) S = throughput $= G \times e^{-2G}$ ($\rightarrow T_{fr}$)

$= 1 \times e^{-2} = 0.135$

b) $G = \frac{500}{\underbrace{1000}_{1\,ms}} = \frac{1}{2}$

c) $G = \frac{250}{1\ ms} = \frac{250}{1000}$.

12.6 → only slot এর শুরুতে frame send করা যাবে ।

↳ slotted ALOHA

(less collision)

vulnerable time = T_{fr}

একটা slot এর transmission time

pure ALOHA vul. time = $2 \times T_{fr}$

slotted → vul. time = T_{fr} " ↓ good

throughput of slotted ALOHA , $S = G \times e^{-G}$

$S_{max} = 0.368 \rightarrow G = \frac{1}{2}$

(Q) Justify কোন scenario তে collision বেশি হয় ? ALOHA or slotted ALOHA

↳ ans. ALOHA তে ।

CSMA → carrier sense multiple access

এই protocol এ one will at first try to find whether anyone is sending frames or not.

• $\boxed{\text{vulnerable time = propagation time}} = \frac{d}{s}$

কতক্ষণ wait time ?

↳ three methods — 1) 1-persistent

→ continuously sense করে (সারাক্ষণ sense → energy loss)

→ collision prob ↑

2) Non-persistent

→ at a time পরপর sense করে

→ collision prob ↓

→ একেকজনের wait time diff. channel free পেতে পারে

disadv : ২ টা source একই time এ sense করে

3) p-persistent

→ consistently sense করে

→ probability of successful transmission ~~success~~

calculate করে → outcome এর basis এ transmission হবে নাকি হবে না decide করে

p.out. ≤ p → can transmit

> p → wait

probability

p > 0.8 → can transmit

otherwise cannot transmit.

12.12, 12.13 → home task

collision in CSMA → at a time 2 টা station transmit করলে

15 . 7 . 2024

$$T_{fr} = \frac{L}{R} = 2T_p$$

$$T_p = \frac{d}{s}$$

ALOHA	CSMA/CD
* persistent method ✗	* persistent method use করে
* Jamming signal ✗	* Jamming signal ✓ ↳ surrounded node will know a collision has occured.
	* Transmission done or collision detection loop এ চলে।

Energy level :

* zero
* normal
* abnormal

noise interference

wired medium → CSMA/CD good

wireless ⟷ collision হয় (noise, interference)

CSMA/CA use করলে cost ↑ nodes collision detect করতে পারে না when distance ↑ * noise * signal fading so we use CSMA/CD

→ collision avoid করতে → CSMA/CA

collision avoidance

CSMA / CA

→ IFS → Inter frame space
  ↳ এই time পর্যন্ত wait করবে

→ contention window → size : binary exponential

K = 3 → R (0 to $2^k - 1$) → | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

can be between

what if , there is not slot empty , then size will increase exponentially .

→ IFS can also be used to define the priority of station or frame
(কোনো node এ data fast send করতে → emergency data
  ↳ IFS ↓)

• IFS ↓ priority ↑ data will transfer fast .

→ idle থাকলে IFS time start হয় (IFS time পরে again we will check channel idle কিনা)
busy " timer stop হয়ে যাবে ।

12.5 :

CSMA/CD

$\hookrightarrow T_{\text{frame transmission time}} = 2 \times T_{\text{Propagation time}}$

Bytes = Bandwidth × time

CSMA/CD :

12.14

→ waiting time $T_B = R \times T_{fr}$
↓
$K\uparrow$ $R\uparrow$ as R is 0 to $2^K - 1$.

wireless → collision detection → not effective
" → " avoidance ✓

end system (pc, phone)
এ থাকবে

VS.?
CSMA/CA → IFS time ✓
CSMA/CD → " " ✗

Controlled access protocol

└→ central controller থাকবে

* Reservation
* Polling
* Token Passing

This slot is reserved

1	0	0	0	0

data station 1

Primary node will select who will send the data packet.

Poll → asks the sender if it has data packet to send. If there's no data, it gives Negative ack.

যার কাছে Token আছে, সে response করতে পারবে।

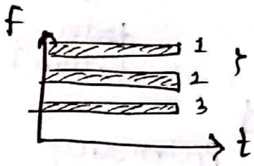
samara

Channelization :

FDMA → Freq division multiple access.

bandpass filter can be used.

Ex : radio channels.

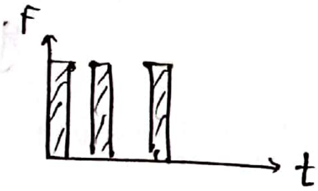


} ২ টা freq এর মাঝে → guard band

to separate the frequencies

vs < FDM → physical layer এ কাজ করে
FDMA → Data Link " " " "

TDMA →



Problem → 1) idle time এ wastage of resource

2) time synchronisation প্রতি channel এ must থাকতে হবে।

Propagation speed maintain করতে

→ guard time

Multiplexer থাকে

vs < TDM → PL (slower channel to faster channel এ পাঠায়)
TDMA → DL layer (access method) allocated time slot দেয়

Multiplexer ✗
algo use হয়

CDMA → • code division

• (citycell এ use হতো)

• f & t are not being divided

• one channel carries all transmissions simultaneously

•

c → code bit

d_1 : $\boxed{1}$ ↓ $d_1 \cdot c_1$

d_2 : $\boxed{2}$ ↓ $d_2 \cdot c_2$

d_3 : $\boxed{3}$ ↓ $d_3 \cdot c_3$

common channel → $\boxed{d_1 \cdot c_1 + d_2 \cdot c_2 + d_3 \cdot c_3}$

Sender end → multiplexing

Receiver " → de- "

$c_1 \neq c_2 \neq c_3$ → chip different generate হয়,

↓ chip generator

Walsh Table

1, 2, 4, 8, 16, 32 value নেয়।

* $W_1 = [+1]$ or $[-1]$

* $W_{2N} = \begin{bmatrix} W_N & W_N \\ W_N & \overline{W_N} \end{bmatrix}$

If, $W_1 = [+1]$, $W_2 = \begin{bmatrix} +1 & +1 \\ +1 & -1 \end{bmatrix}$, $W_4 = \begin{bmatrix} +1 & +1 & +1 & +1 \\ +1 & -1 & +1 & -1 \\ +1 & +1 & -1 & -1 \\ +1 & -1 & -1 & +1 \end{bmatrix}$

W_2 ↓ 2 stations (c_1, c_2)

W_4 ↑ 4 stations (c_1, c_2, c_3, c_4)

$W_8 = \begin{bmatrix} W_4 & W_4 \\ W_4 & \overline{W_4} \end{bmatrix}$

If station number is 6, then W_8 will be used.

Scanned with CamScanner

$c1 \rightarrow +1 \quad +1 \quad +1 \quad +1$

$c2 \rightarrow +1 \quad -1 \quad +1 \quad -1$

$c3 \rightarrow +1 \quad +1 \quad -1 \quad -1$

$c4 \rightarrow +1 \quad -1 \quad -1 \quad +1$

} chip sequences.

data bit $0 \rightarrow -1$

" " $1 \rightarrow +1$

Silence $\rightarrow 0$

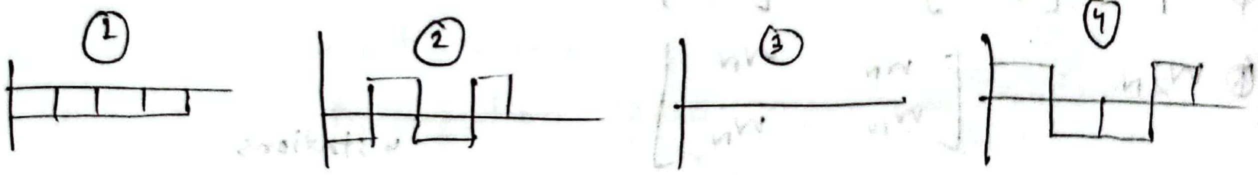
} data representation

Sharing channel in CDMA

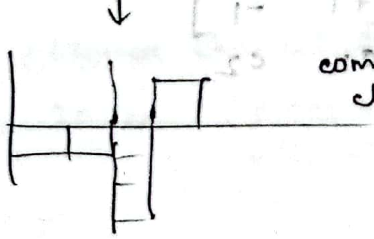
	bit 0	bit 0	silent	bit 1
	-1	-1	0	$+1$
	c_1 [1]	c_2 [2]	c_3 [3]	c_4 [4]
	d_1c_1	d_2c_2	d_3c_3	d_4c_4
	[-1 -1 -1 -1]	[-1 +1 -1 +1]	[0 0 0 0]	[+1 -1 -1 +1]

$\downarrow d_1c_1 + d_2c_2 + d_3c_3 + d_4c_4$

data = [-1 -1 -3 +1]

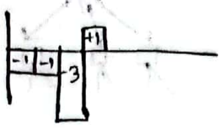


$\downarrow$

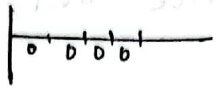


common channel

16
4 32
5 64
6 128
7



Station 3



$$[-1 \; -1 \; -3 \; +1] \cdot [0 \; 0 \; 0 \; 0] = \underbrace{[0 \; 0 \; 0 \; 0]}$$

$$\frac{\text{Sum } 0}{\text{stations } 4} = 0 \rightarrow \text{Silent.}$$

Station 2 :

$$[-1 \; -1 \; -3 \; +1] \cdot [+1 \; -1 \; +1 \; -1]$$

$$= [-1 \; +1 \; -3 \; -1] \quad \frac{\text{sum} = -4}{4}$$

$$= -1 \rightarrow \text{bit } 0$$

Station 1 :

$$[-1 \; -1 \; -3 \; +1] \cdot [+1 \; +1 \; +1 \; +1]$$

$$= [-1 \; -1 \; -3 \; +1] \quad \text{sum} = -4$$

$$\text{So, } \frac{-4}{4} = -1 \longrightarrow \text{bit } 0$$

If there is 90 stations, $m = 7$ so, W_{128} has to be determined

12.8 → home task.

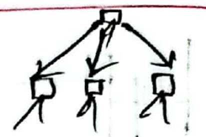
CHAPTER 14   15.5.2024

FERNEZ MA'AM

WIRELESS LANS

BSS → Basic ~~Station~~ service set

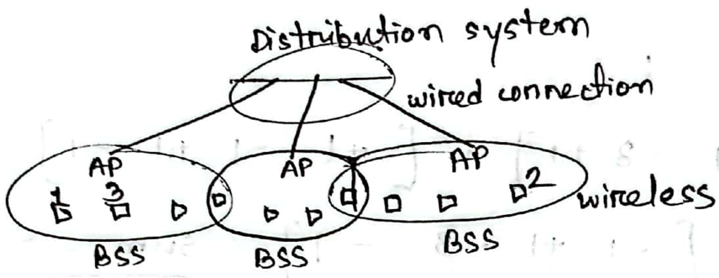
AP → Access Point



BSS without AP → ad hoc network (bluetooth)

BSS with AP → Infrastructure (sensors)

ESS → Extended service set (more than one BSS)
→ Infrastructure



stationary/mobile system

→ can be in more than one BSS

1 to 2 তে packet transfer এর জন্য AP needed.

1 to 3 " " " " " isn't ".

* BSS → cell
AP → Base station } cellular communication

* No transition → mobility নেই (1টা particular BSS এই থাকে)

BSS " → moving from one BSS to another

ESS "
→ moving from one ESS to another.

DL L
- LLC sub layer — IEEE 802.1
- *Mac sub-layer — Point coord. func. PCF → Infra. s এ use হয় ; not in ad hoc
- Distribution " " DCF

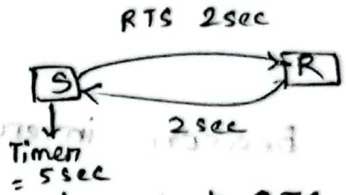
PL — 802.11

CSMA / CA flowchart :

- back off , k = 0
- Persistence strategy → 1P / NP / P-persistent

Energy L = 0 → channel idle
" " ≠ 0 → " এ packet transfer হচ্ছে

- Distributed IFS → wait
- Send 'Ready to send' msg.
- set timer
- CTS before time out ?
- If received, wait SIFS (↓ short)
- Send frame.
- set timer → Ack পেয়েছে নাকি check করলে ; পেলে successfully transmitted data.

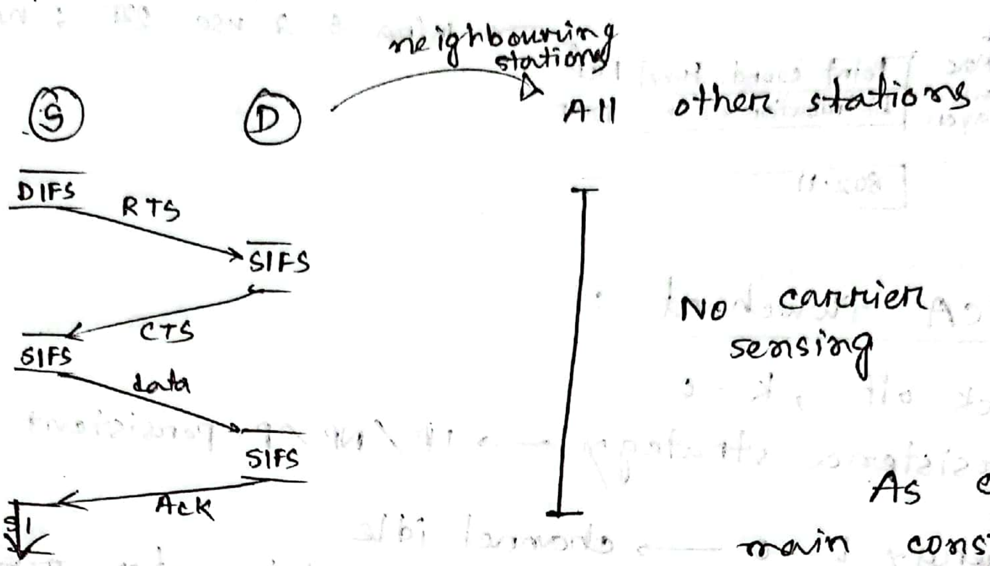


↳ check CTS পেয়েছে কিনা

collision avoid এ প্রয়োজন
IFS
RTS
CTS
network এর জন্য overhead
→ these are called handshaking

PCF AP কে Priority বেশি দিচ্ছে (IFS↓)
→ Infra. Network এ use হয়
→ Polling access method

NAV time
↳ Network Allocation vector



As energy is main constraint. অন্যসব station data sense-ই করে না।

Beacon interval ⟶ start to end time of sending data packet

* Fragmentation ⟶ cost effective

(2 byte) FC ⟶ Frame type, control information
subtype (4 bit) ⟶ RTS, CTS, data
Retry (1bit) ⟶ Retransmission ↑ channel collided.
More data (1bit) ⟶ আরো data send করার বাকি

(2 byte) D ⟶ Frame duration ≈ 10 sec ⟶ অন্য stations NAV time এ থাকবে

(4x 6bytes) Address 1 to 4
↳ কোন access point থেকে কোন AP তে যাচ্ছে

SC ⟶ sequence control

Frame body → 0 to 2312 bytes

FCS → Trailer (CRC - 32)
↳ 4 bytes.

~~FC → Pwr mgt~~

2B	2B	6B	6B	4B
FC	D	Ad 1	Ad 2	FCS

RTS

2	2	6	4
Fc	D	Ad 1	FCS

CTS & AcK

22.9.2024

TO DS   FROM DS

1 bit   1 bit

4 combination → address decide হয়।

00 → same BSS

1	2	3	4
Dest	Source	BSS ID	NULL

01 → অন্য BSS থেকে আসছে

1	2	3	4
Dest	Sending AP	source	NULL

10 → অন্য BSS এ যাবে।

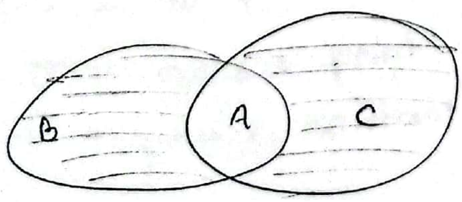
1	2	3
sending AP	source	Destination

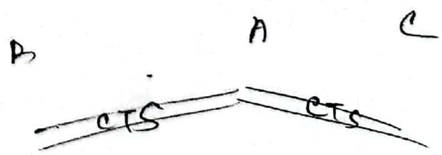
11 → one BSS to another

1	2	3	4
Receiving AP	Sending AP	Dest	Source

Hidden Station Problem :

wireless medium এর problem





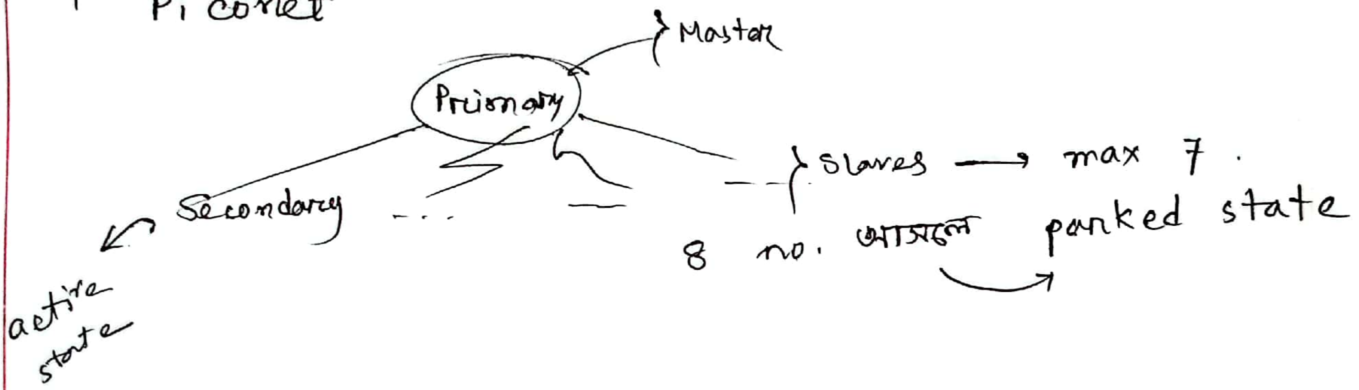
Exposed Station Problem :

C এর Range এ D থাকলে, ও data send করতে পারবো। but as CTS পেয়েছিল, C over cautious হয়ে যায়। সে এখন data send করবে না।

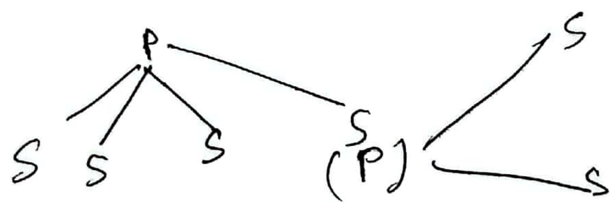
14.4 X

Bluetooth :

* Piconet



* Scatternet



Single secondary :

odd slot → primary
even " → secondary

TDMA (Time এ ভাগ করে

Multiple Secondary : যাকে Poll করবে সেখানে যাবে।

syn connection oriented (SCO)

Asy " less (ACL)

error থাকে
হবার time ↓
হাত হবে।

Ex : audio call

must be error free
delay থাকে হেতো