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# Computer Networks

## Different layers of OSI model. → to transfer data from one computer to another

top most ① Application layer → to select data from application what data to send.

Why is data transfer divided into layers?
→ to easily detect errors & recover easily
→ to account for difference in speed of network.
→ No problem in synchronization b/w sender & receiver for flow control (speed)

ultimate ultimate
Host to destination → path contains many nodes.
sender receiver

② Presentation layer : data can be converted, compressed.

③ Session layer → time for each activity is maintained here. size of data, speed of n/w.

④ Transport layer → division of data into segments. There is flow control & error control. Synchronization b/w receivers & senders: transport layer
(senders & receivers are ultimate host & destination)

⑤ Network Layer → segments are divided into packets. It has techniques for traffic control & congestion detection.

⑥ Data Link Layer → Data is in format of Frames (Data is in binary format)

⑦ Physical layer → data in form of signals, wired or wireless media
from sender's PL to receivers PL & then ~~receivers~~ reverse process happens.

sender: AL, PL, SL, TL, NL, DLL, PL → PL (Receiver, upward)

Can two networks have same IP address?

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# Physical layer

Q# How are systems interconnected? each node directly every other
Network topologies → ring, mesh, star, Bus
(complete graph)

Q# devices at physical layers
→ Hubs & Switches

Bus : one fault disrupts
→ only single directional transmission at a time
Circular → ~~removes~~ remedies above fault
Mesh :- more wire
Star → central device called hub is connected to each device. All transfer occurs through it.

# DATA LINK LAYER [FRAMES OF BINAR INFO = DATA]
- if there is an error from one DLL to other.
sender & Receiver at data link layer = every intermediate node
↳ every frame is checked if corrupt or not
Network layer → error checking at every router
Router → a system (server)
intelligent device to connect different network.

Physical Address → at PL & DLL → 64 bit
32 bit Network layer → 4 byte IP address (can change, assigned by admin of network)
~~Session layer~~ →
Port Address →

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# FRAMING TECHNIQUES

↳ dividing data into frame as well as error checking by receiver.

1. Fix frame length { But real world data can't be fixed }

2. Frame Header.
   - contains information about frame.
   - ~~Fra~~ frame length.

<u>drawback</u> → what if Header itself becomes corrupt then frame length can't be obtained.

# Technique to Resolve Frame Header Corruption. (Frame length field)

① Character Stuffing → assume that a particular character indicates the frame's end. If it is reached, then right frame.

e.g → F | 0 | 1 | 1 | 0 | F | 0 1 | F

bits

won't match with data bits as we have taken a character.

<u>drawback</u> - size of character is 8 bit hence frame size increases.

② <u>Bit Stuffing</u> → we assume that a particular bit pattern indicates frame end e.g 11111

<u>drawback</u> → pattern occurs in data.

↳ resolved by → inserting zero at the ~~end~~ n-1th position of pattern in data. This is done by sender in synchronization with receiver.

<u>111101</u>

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Questn → suppose 0111 indicates frame end.
Data = 01100110 11
what is transmitted data ???

~~ptt pplalbl~~

011$\boxed{0}$0011$\boxed{0}$0111$\boxed{0}$

Data → 01110110

011$\boxed{0}$10110$\boxed{0}$0

Functions of DLL → error control of frames.
→ ensure sender's data is received correctly by receiver.

ERROR CONTROL
— detection & correction.

(1) VRC → VERTICLE REDUNDANCY CHECK
→ some redundant bits are inserted by sender, they are removed by receiver
→ Per data unit we add a single redundant bit called PARITY BIT.

→ odd parity or even parity

~~if no of ones odd including~~
if no of 1's are odd → then no problem add 0 else add 1.

1101011$\boxed{0}$

drawback → if no of bits changed in even no,

Can't detect more than 1 bit error.

0 or 1's added after every fixed length → vertical division

Hamming CODES

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→ can detect as well as correct

# LRC → LONGITUDINAL REDUNDANCY CHECK

16 bit

| | | | | |
|---|---|---|---|---|
| 1 | 0 | 0 | 1 | 1 |
| 1 | 1 | 1 | 0 | 0 |
| 1 | 0 | 1 | 1 | 0 |
| 1 | 1 | 0 | 1 | 0 |
| 1 | 1 | 1 | 0 | RB |

⇐ Redundant bit

applied by check

can correct only single bit error

can detect 2 bit errors.

# CRC ⇒

11/9/18 Flow Control :- To synchronize the speed of sender & reciver

Protocols of flow control :

1. Simplex :- Drawback :- receiver can't send the cont by one way communication
2. Half Duplex → both send & receive the data only at a time.
3. Full Duplex → communication happens simultaniously

channel type

# Stop & wait protocol : uses ~~simplex~~ half duplex

senders sends the data and waits for acknowledgment.

Next frame sent only after.

drawback : reciever & sender both wait. May result in deadlock.

How long should they wait

Resolved :- using time out period. wait only for that time.

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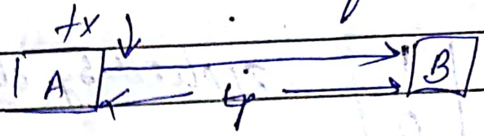
transmission time : $t_x$ : time to keep frame on the media → for all the bits

propogate $t_p$ : time to take data from A to B { single bit from sender }




# $\boxed{\text{Round trip time RTT}} = t_x + 2t_p$.

Sender waits for ≥ 1 RTT for acknowledgment otherwise, retransmission occurs.

$t_{xA}$ : $t_x$ for acknowledgment { only bit is kept can be ignored }

$t_x + t_{xA} + t_p + t_{pA}$

Q: Frame length → L bit long. Put that frame on media.

transmission $t_x = \dfrac{L}{R}$ { length of media / Data transfer rate

Propogation $t_p = \dfrac{D}{S} = \dfrac{\text{Distance from A to B}}{\text{signal speed}}$

Data transfer Rate → default bit / sec
Mbp's
MBps.

Q: Calculate $t_x$ for 1000 byte frame for 100 mbps channel.

$t_x = \dfrac{1000 \times 8}{100 \times 10^6 \text{ b/s}} = 80$ micro seconds

Q: calculate $t_p$ for 3000 km apart & signal travels at 2/3 speed of light

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$$t_p = \frac{3 \times \cancel{3}000 \times 10^3}{2 \times \cancel{3} \times 10^8} = \frac{}{1000}$$

$= 0.015$ sec

# Efficiency of Stop & Wait Protocol. { ratio of out

with respect to sender $\eta = \frac{t_x}{t_x + 2t_p}$ or $\frac{t_x}{RTT}$

# PIGGYBACKING

if data has to be sent by receiver as well acknowledgment bit is appended to data

here acknowledgment time = frame transmission time ($t_x = t_{xA}$)

Q. 4 Kbps channel. Find efficiency of stop & wait protocol to send the frame of 1000 bits over 3000 KM long channel when signal propagates at $3 \times 10^8$ m/s.

$t_x = \frac{1000 \text{ b}}{4 \times 10^3 \text{ b/s}}$ 0.25 seconds.

$t_p = \frac{\cancel{3}000 \times 10^3 \text{ m}}{\cancel{3} \times 10^8 \text{ m/s}}$ $\frac{1}{100}$ sec $= 0.01$ sec

$\eta = \frac{0.25}{0.25 + 0.02} = \frac{0.25}{0.27} \times 100 = 92.59\%$

# Effective Data Rate / Throughput

= efficiency * Data transfer Rate

= $92.59 \times 4$ kbps =

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# Error control
CRC Hamming code → self

Q. $t_p = 20 \times 10^{-3}$ sec (ms). Data transfer rate = 4 Kbps.

$\eta = 50\%$, find L.

$\frac{1}{2} = \frac{t_x}{t_x + 40ms}$ ⇒ $\frac{t_x}{2} + 20ms = t_x$ ; $20ms = \frac{t_x}{2}$ ⇒ $t_x = 40ms$.

$\frac{40}{10^{-3}} \times \frac{1}{4 \times 10^3}$ = 160 ms

Q. Stop & wait protocol give $\eta = 100\%$ when $t_p = 0$.
→ not possible

# SLIDING WINDOW PROTOCOL

→ window size is decided by synchronization b/w sender & receiver

W = window size = no of frames we can keep on transmitting before getting acknowledgement.

| F3 | F2 | F1 | F0 |

As we get acknowledgement we can ~~keep~~ add more frames in window.

$$\eta = \frac{W t_x}{t_x + 2t_p}$$

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Question 4 mbps channel with 1000 km → D between two stations. Frame size = 1000 bits. Data speed = 200 m/µs. Calculate $\eta$ of sliding window protocol. W = 5

$\eta = 12.19\%$

calculate optimum window size.

$t_x = \frac{1000 \times 10^6}{4 \times 10^6 \text{ bits}} = 250 \mu s$

$t_p = \frac{1000 \times 10^3}{200} \Rightarrow 5000 \mu s$

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4 3 2 1 0
2 1 0 4 3
3 2 1 0 3

Frame is n bit
0 to 15

$1 = \frac{W \cdot 250}{250 + 10000} = \frac{10250}{250} = W$

$= \boxed{41}$

# Sliding window Protocol = Every frame has a sequence number.

↳ 0 to n-1. if there are n frames.

if 3rd frame is corrupted, reciever returns 3 {no of frame sequence}

0 1 2 3 4 ⟶ 0 1 2 4

if higher

$\xleftarrow{3}$

sender resends that frame again ⟶ 3 4 0 1 2

# Techniques (Protocol if there is error in Sliding Window Protocol)

① I- SelectiveRepeat Protocol

→ only those frames are retransmitted which have error

→ window size can change on getting error

↳ Formula for new window size

→ W=5 (0-4)

$W = \frac{max\ seq}{2} + 1$

if w = n then max seq = n-1

② Go back

all frames after error are resent.

↳ window size = max sequence.

# For n bit frame → Max sequence

$\frac{2^n}{2} = 2^{n-1}$

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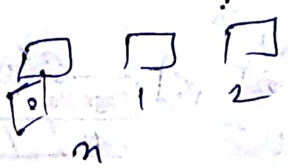
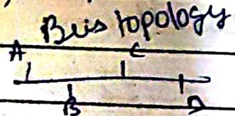



# Max window size of sender & Receiver.
1. Stop & wait protocol $\Rightarrow 1$
2. ~~Selecte~~ sliding window protocol $\Rightarrow 2^n$
3. selective repeat $\Rightarrow W = \frac{2^n}{2} = 2^{n-1} \left( \frac{2^n - 1 + 1}{2} \right)$
4. Go back & N $\Rightarrow$ max seq $= 2^n - 1 = W$
↳ $\boxed{\text{receiver window size is 1}}$
only used when this applies

Q. Go back N protocle. W = 4. → max seq is also 4
situation: frame no's are from $\underline{0 \to 4}$ =

if we transmit frame [0 1 2 3]. Now if acknowledgment sent by receiver is 3 & 3 is corrupt.

# Data Link Layer (Node to Node communication)
logical link control — LLC
media access control — MAC — used in LAN transmission.
{Frame contains physical address of source & destination}




# 4. MAC layer protocols to detect the collision.
1. Carrier Sense Multiple Access Protocol CSMA
↳ theoretical only
CSMA - CD
2. Ethernet
→ senses media if voltage is high
if data is already present
sends after completion
3. Token Ring
4. ALOHA

To sense the channel, there are 3 techniques
→ 1 - persistant
→ P - persistant
→ n - persistant
} determine after what amount of time, sense the channel again.

# 1-persistant

sense the channel continuously. when free sends data immediately with probability 1.

# p-persistant ⇒ sense & transmits with probability p.

# n-persistant (Not persistant). If channel is busy. wait for random amount of time.

# CSMA-CD : with collision detection
Numerical
sendor checks
There may be chances that data is on the channel but no collision will take place