EXAM QUESTIONS

True or false

1. The MAC address of a node changes if the node is moved from a network to another. [T/F] FALSE
2. Two end systems belonging to two different LANs can have the same IP address. [T/F] TRUE
3. The Slow Start phase is implemented in TCP Reno. [T/F] TRUE
4. Pure Aloha protocol is more efficient than slotted Aloha. [T/F] FALSE
5. The field Source Address in a frame header does not change when traversing a router. [T/F]
6. ARP is a Routing Protocol. [T/F]

2) YES, BECAUSE OF THE LAYER OF LOCALITY PROVIDED BY THE NAT.

3) TCP RENO IS A VERSION OF TCP THAT FIRST INTRODUCED THE FAST RECOVERY.

TCP, UP UNTIL THAT POINT, SUPPORTED:

- CONGESTION WINDOW
- SLOW START

CONGESTION WINDOW:

A CONGESTION WINDOW IS A CONSTRAINT ON THE RATE OF TX.
IT LIMITS THE AMOUNT OF UNACKNOWLEDGED DATA.
AT THE START OF EVERY RTT, THE NODE CAN

ONLY SEND CWND BYTES INTO THE NETWORK.

SENDER RATE : $\frac{CWND}{RTT}$ BYTE/S

THE SIZE OF THE CONGESTION WINDOW DEPENDS ON THE ACKNOWLEDGEMENTS.

PACKET LOSS IS TAKEN AS SIGN OF CONGESTION AND WILL DECREASE CWND. (4 DUPLICATE ACKS, 1 ORIGINAL AND 3 COPIES)
IF ACKS ARRIVE FAST, CWND INCREASES QUICKLY, IF THEY ARRIVE SLOWLY, CWND WILL INCREASE SLOWLY.

SLOW START:

CWND IS INITIALIZED AT 1 MSS (COULD BE MSS = 500 BYTES). CWND INCREASES BY 1 MSS EACH TIME A SEGMENT IS FIRST ACKNOWLEDGED.

THIS RESULTS IN DOUBLING THE CWND EVERY RTT.

1 → 1 ACK → + 1 = 2
2 → 2 ACKS → + 2 = 4
4 → 4 ACKS → + 4 = 8

EXPONENTIAL GROWTH

IT STOPS WHEN A LOSS OCCURS,

THEN CWND IS SET TO 1 AND SLOW START RESTARTS.

AT TIME OF LOSS

ALSO, SSTHRESH IS SET TO CWND/2.

SLOW START STOPS WHEN IT REACHES SSTHRESH, THE ALGORITHM ENTERS IN CONGESTION AVOIDANCE MODE.

CONGESTION AVOIDANCE MODE:

JUST INCREASES BY 1 MSS, ONCE EVERY RTT.

EITHER TIMEOUT OR DUPLICATE ACKS

WHEN A LOSS OCCURS, WE DO THE SAME AS BEFORE, WE SET CWND TO 1 AND SSTHRESH AT CWND/2.

FAST RECOVERY:

ONLY TRIGGERED BY DUPLICATE ACKS, BECAUSE IF WE RECEIVED THOSE ACKS, IT MEANS THAT CONGESTION IS NOT SEVERE, SO THE MEASURES SHOULD BE LESS DRASTIC.

CWND IS INCREASED BY 1 FOR EACH DUPLICATED ACKS THAT CAUSED THE FAST RECOVERY.

WE REMEMBER THAT WE STILL SET CWND TO 1 AND SSTHRESH TO CWND/2 BEFORE ENTERING FAST RECOVERY.

IF TIMEOUT OCCURS DURING FAST RECOVERY, WE SET CWND TO 1 AND SSTHRESH TO CWND/2, THEN PASS TO SLOW START.

THIS WAS FIRST IMPLEMENTED IN TCP RENO.

4) PURE ALOHA IS SLOWER THAN SLOTTED ALOHA.

PURE ALOHA:

IN PURE ALOHA, EVERYONE SENDS THEIR FRAMES RANDOMLY, IF A NODE DETECTS A COLLISION, THE NODE WILL:

- FINISH TO TRANSMIT

TRANSMIT

- SUCCESS = TRANSMIT (PACKET)

```
P = 0.5
WHILE NOT SUCCESS:
    IF RANDOM_FLOAT(0,1) < P:
        SUCCESS = TRANSMIT (PACKET)
    ELSE:
```

IF COLLISION RETRY

IF COINFLIP SUCCEEDES SEND

ELSE WAIT THEN RETRY

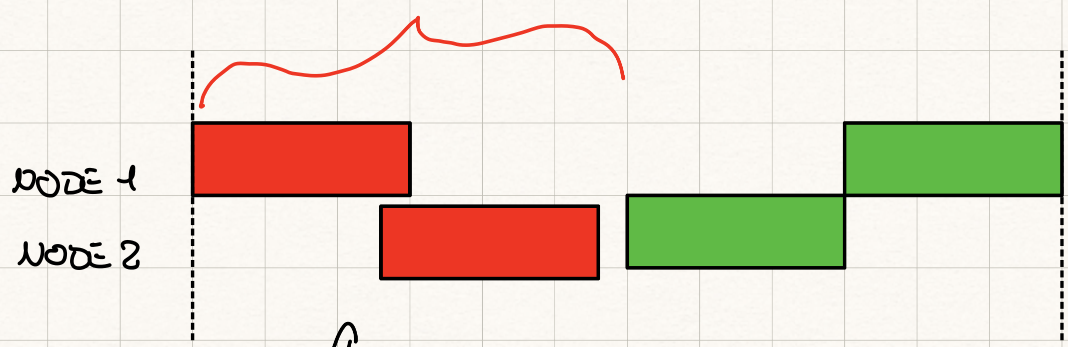
WAIT (FRAME_TX_TIME)

VULNERABLE TIME OF PURE ALOHA

BY VULNERABLE TIME WE MEAN THE TIME IN WHICH NO FRAMES SHOULD BE SENT, TO AVOID ANY COLLISIONS.

IN PURE ALOHA, FRAME CAN BE SENT AT ANY TIME, AND THE WORST CASE OF COLLISION HAPPENS LIKE THIS.

VULNERABLE TIME = 2 · TRANSMISSION TIME

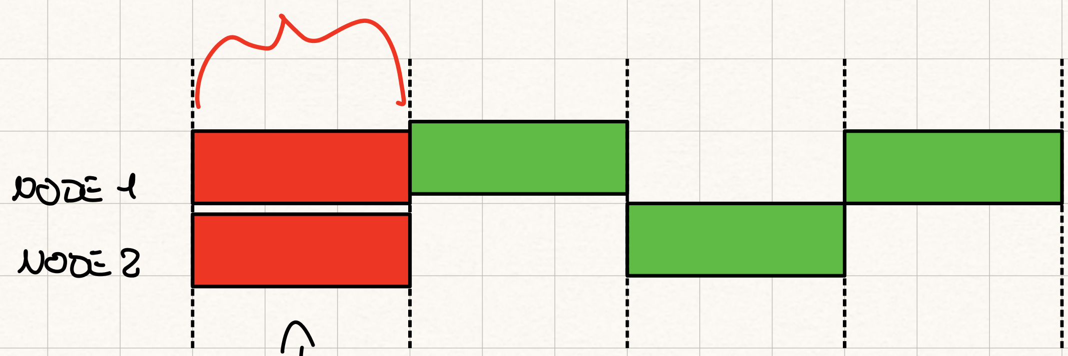


FRAME STARTS JUST BEFORE THE END OF THE PREVIOUS ONE.

SLOTTED ALOHA:

IN SLOTTED ALOHA, IT IS EQUAL TO THE TRANSMISSION TIME, SINCE IT IS DIVIDED IN SLOTS AND NODES MUST ALWAYS TRANSMIT AT THE BEGINNING OF THE SLOT.

VULNERABLE TIME = TRANSMISSION TIME



THIS IS THE ONLY WAY OF HAVING A COLLISION, BECAUSE IN THE SAME SLOT THEY CAN ONLY START AT THE SAME TIME

5) I DON'T HAVE A FUCKING CLUE.

6) ARP IS NOT A ROUTING PROTOCOL

ARP

ARP STANDS FOR "ADDRESS RESOLUTION PROTOCOL", IT TRANSLATES IP ADDRESSES TO LINK LAYER ADDRESSES.

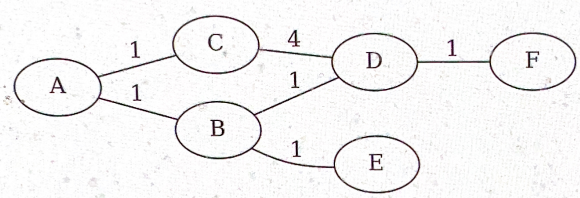
IF DEVICE WANTS TO CONNECT ANOTHER DEVICE ON THE LAN, IT NEEDS A MAC ADDRESS (LAYER 2 ADDRESS).

IF WE DON'T ALREADY HAVE THE DEVICE
IN THE ARP TABLE,
WE SEND A SPECIAL ARP PACKET INTO
THE NETWORK. (WITH DESIRED IP ADDR. TARGET)

THE TARGET DEVICE WILL RESPOND WITH
IS OWN MAC ADDRESS.

TODO: WRITE MORE ABOUT ARP PACKETS

1. Calculate the **entries of the routing tables** at routers A and D, for the first three rounds of a distance vector routing protocol, using the distance metric for the following example:



FOR Y IN DESTINATIONS:

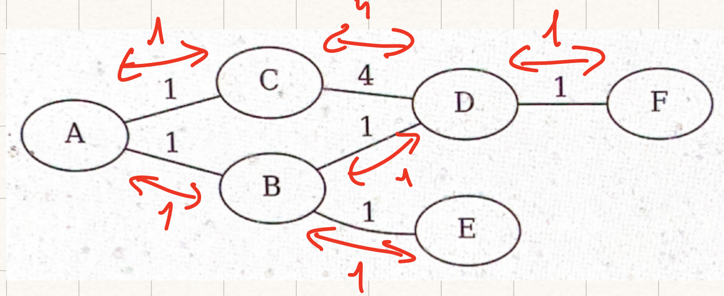
DISTANCES FROM X

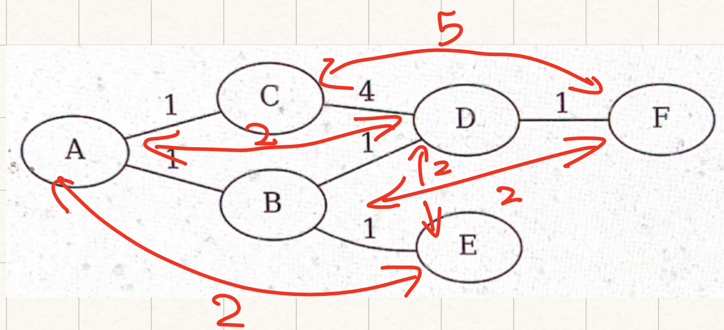
DISTANCE FROM NEIGHBOUR TO Y

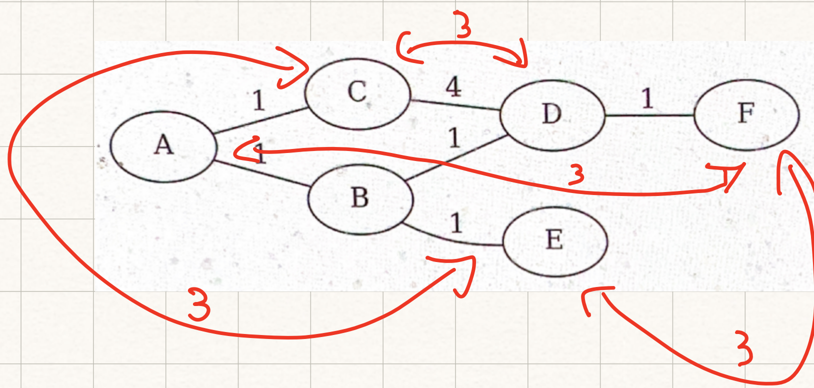
Dx[Y] = MIN(NEIGHBORS, KEY= lambda v: D[v]+Dv[Y])

IF OLD_Dx != Dx:

SEND_Dx_TO_NEIGHBORS()







I CAN'T DO THIS

2. A TCP server has received and acknowledged up to byte 2500. Explain the actions that the server will take following the given events:

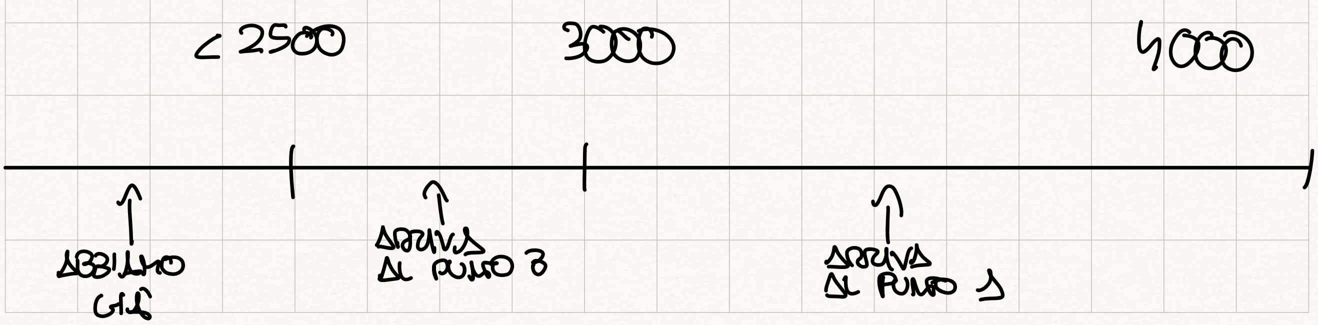
   a) The server receives a 1000-byte segment with sequence number 3001.
   b) The server receives a 500-byte segment with sequence number 2501.
   c) The server receives a 500-byte segment with sequence number 2001.
   d) The server receives a 500-byte segment with sequence number 3501.

THE SEQUENCE NUMBER FOR A SEGMENT IS THE NUMBER OF THE FIRST BYTE IN THE SEQUENCE.

TCP ONLY ACKNOWLEDGES BYTES UP TO THE FIRST MISSING BYTE.
BECAUSE OF THIS, TCP IS SAID TO PROVIDE CUMULATIVE ACKNOWLEDGEMENTS.

IN THIS CASE,

a) SERVER WILL ACK 2501
b) SERVER WILL ACK 4001
c) SERVER WILL ACK 4001
D) SERVER WILL ACK 4001



3. A network using CSMA/CD has a bandwidth of 10 Mbps. If the maximum propagation time is 51.2 μs, what is the minimum size of the frame?

THE FORMULA FOR MINIMUM FRAME SIZE IS

$b \cdot 2 \cdot t_{PROPAGATION}$.

t_{PROP} IS IN ALWAYS IN MICROSECONDS,
ALSO Mbps MEANS MEGA BIT PER SECOND, SO
WE SHOULD CONVERT TO BYTES.

$10 \cdot 2 \cdot 51{,}2 = 1024$ BITS

$1024/8 = 128$ BYTES

4. Consider a datagram network using 8-bit host addresses. Compute the number of addresses that are routed through each interface, assuming that the router uses longest prefix matching and has the following forwarding table:

	Prefix match	Interface
1	0	0
2	001	1
3	0100	2
4	11	3
5	1	2

256 ADDRESSES

3 → 16 ADDRESSES 2^4

2 → 32 ADDRESSES 2^5

4 → 64 ADDRESSES 2^6

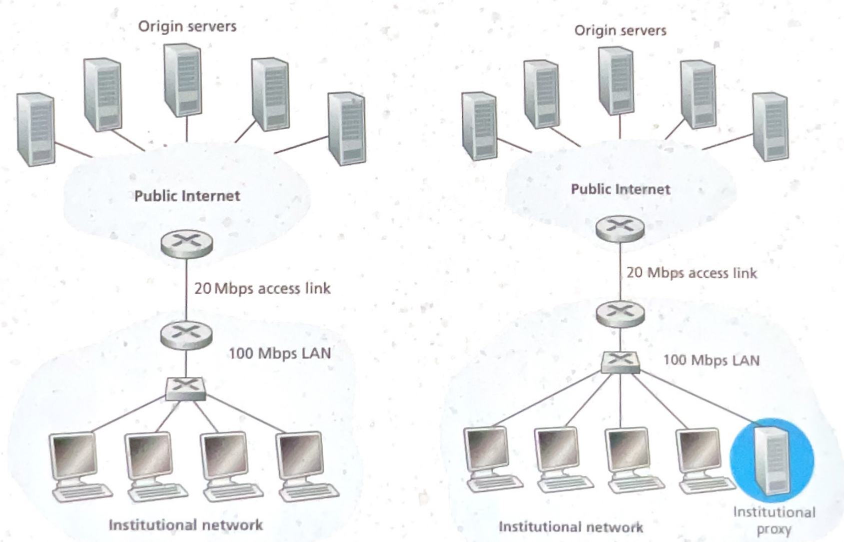
5 → 128 − 64 ADDRESSES $2^7 - \{4\}$

1 → 128 − 48 ADDRESSE $2^7 - \{2\} - \{3\}$

TOTAL = 256

5. Consider Scenario 1. An institutional network utilizes a 20 Mbps link to connect to the public internet and reach some origin web servers. The content files stored on the origin servers have an average size of 100 Kbits. The cumulative request reate from the institution browsers is 150 req/sec. The time between the moment in which the router on the internet side of the access link forwards an HTTP request to the origin servers and the moment in which it receives a response from them is 5 seconds (internet delay). Assume that HTTP requests are negligibly small. Consider Scenario 2 where the institutional network adopts a proxy server which serves requests within the LAN in 5 msecs, with an average hit rate of 0.7. With the proxy, the average access link delay experienced by requests drops to 10 msecs.

   a) Calculate the utilization of the LAN and of the access link in Scenario 1.
   b) Calculate the utilization of the access link in the second scenario.
   c) Calculate the average delay experienced by the requests in the second scenario.



a)

$$\text{TRAFFIC INTENSITY / UTILIZATION} = \frac{\text{TRAFFIC IN MBPS}}{\text{CABLE SPEED}}$$

IN THIS CASE : $\dfrac{150 \text{ REQ/s} \cdot 0{,}1 \text{ MBITS/REQUEST}}{20 \text{ Mbps}} = 75\%$

b) STILL 0.75, BUT WITH HIT RATE = 0.7,
IT'S $0.75 \cdot 0.7 = 0{,}53$

c) 30% OF REQUESTS ARE 5 s
70% OF REQUEST ARE 0,005 s

APPARENTLY AVERAGE LINK DELAY IS

$0{,}3 \cdot 5 + 0{,}7 \cdot 0{,}005$

BECOMES 0,01 WHEN WE PUT IN
THE $\gamma\gamma$
BECAUSE ACCESS LINK UTILIZATION
HAS DECREASED.

$0{,}3 \cdot 0{,}01 + 0.7 \cdot 0{,}005 = 0{,}0065 = 6{,}5 \text{ ms}$

6. Consider sending a large file of F bits from host A to host B. There are three links and two switches between A and B. Host A segments the file into segments of S bits each and adds 60 bits of header to each segment, forming packets of $L = 60 + S$ bits. Each link has a transmission rate of R bps. Find the value of S that minimizes the delay of moving the file from host A to host B, disregarding queueing and propagation delays.

DELAY END TO END $= N_{\text{SWITCHES}} \cdot (d_{\text{PROCESSING}} + d_{\text{TRANSMISSION}} + d_{\text{PROPAGATION}})$

HERE WE JUST HAVE THE TRANSMISSION DELAY, SO

$$d_{\text{TRANSMISSION}} = \frac{L \text{ BITS}}{R \text{ TRANSMISSION RATE}} = \frac{60 + S}{R}$$

↑ TIME REQUIRED TO PUSH ALL THE BITS INTO A LINK.

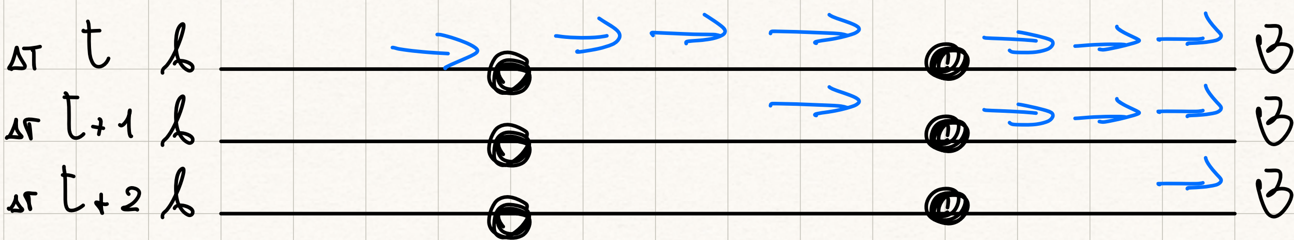
WE DON'T MULTIPLY BY 3 ROUTERS BECAUSE THOSE DELAYS DON'T STACK.

N OF PACKETS $= \frac{F}{S}$

THE PACKETS ARE SENT ASYNCHRONOUSLY, EXACTLY WHEN THE SECOND ROUTER FINISHES SENDING A PACKET, ANOTHER ONE ARRIVES, NO TIME WASTED.
THOSE DELAYS DON'T STACK.

AT TIME $\frac{60+S}{R} \cdot \frac{F}{S}$ THE LAST PACKET IS SENT, BUT STILL HASN'T ARRIVED TO DESTINATION. SO WE NEED TO ADD $\Delta * 2$, BECAUSE 2 ADDITIONAL ROUTERS.

$$t = \frac{60+S}{R} \cdot \frac{F}{S}$$



SO WE HAVE $\frac{60+S}{R} \cdot \left(\frac{F}{S} + 2\right)$

NOW WE TAKE THE FUCKING FIRST DERIVATIVE, AND TO FIND THE MINIMUM WE POSE IT $= 0$.

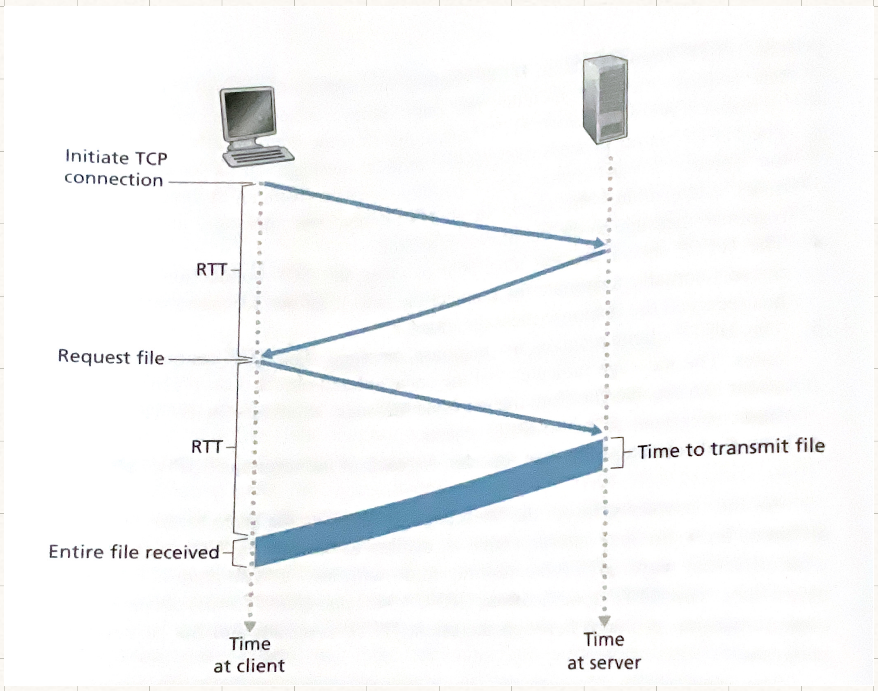
THE RESULT IS $\sqrt{30F}$.

60/2

OTHER STUFF

RTT

IT STANDS FOR "ROUND TRIP TIME", IT'S THE TIME IT TAKES FOR A SMALL PACKET TO TRAVEL FROM CLIENT TO SERVER AND THAN BACK TO THE CLIENT.



TCP TIMEOUT

TCP USES A TIMEOUT/RETRANSMIT MECHANISM TO RECOVER FROM LOST SEGMENTS.

OBVIOUSLY, THE TIMEOUT SHOULD BE BIGGER

THAN THE RTT.
SO WE NEED TO ESTIMATE THE RTT.

SAMPLE RTT

MEASURED RTT FOR A SEGMENT.
IT'S THE TIME BETWEEN WHEN THE SEGMENT IS SENT AND WHEN THE ACKNOWLEDGEMENT IS RECEIVED.

WE DON'T NEED TO MEASURE EACH SEGMENT, WE CAN JUST MEASURE ONCE PER RTT FOR EXAMPLE.

WE DON'T CALCULATE SAMPLE RTT FOR RETRANSMITTED SEGMENTS.

ESTIMATED RTT

TCP MAINTAINS AN AVERAGE OF THE SAMPLE RTT VALUES.

EVERY TIME WE OBTAIN A NEW SAMPLE RTT VALUE, WE UPDATE ESTIMATED RTT ACCORDING TO THIS:

$$\text{EstimatedRTT} = \underbrace{(1-\alpha)}_{0.875} \cdot \text{EstimatedRTT} + \underbrace{\alpha}_{0.125} \cdot \text{SampleRTT}$$

THIS WEIGHTS PUT MORE WEIGHT ON OLD SAMPLES.

DEV RTT

ESTIMATE OF HOW MUCH SAMPLE RTT TYPICALLY DEVIATES FROM ESTIMATED RTT.

DEV RTT IS AN EWMA OF THE DIFFERENCE BETWEEN SAMPLERTT AND ESTIMATED RTT.

$$\text{DevRTT} = (1 - \beta) \cdot \text{DevRTT} + \beta \cdot |\,\text{SampleRTT} - \text{EstimatedRTT}\,|$$

TIMEOUT INTERVAL

IT SHOULD BE BIGGER THAN ESTIMATED RTT.

THE ADDED MARGIN SHOULD BE SMALL WHEN THERE IS LITTLE FLUCTUATION, HIGH WHEN THERE IS A LOT.

$$\text{TimeoutInterval} = \text{EstimatedRTT} + 4 \cdot \text{DevRTT}$$

AN INITIAL VALUE OF 1 IS RECOMMENDED.

WHEN A TIMEOUT OCCURS, THE TIMEOUT IS DOUBLED UNTIL ESTIMATED RTT IS UPDATED.

CSMA/CD

CSMA STANDS FOR CARRIER SENSE MULTIPLE ACCESS.

CARRIER SENSING

CARRIER SENSING MEANS THAT IF SOMEONE ELSE IS SPEAKING, YOU SHUT UP UNTIL THEY ARE FINISHED.

COLLISION DETECTION

CD STANDS FOR COLLISION DETECTION, MEANING THAT YOU MUST STOP TALKING IF SOMEONE STARTS AT THE SAME TIME AS YOU (TO AVOID WASTING TIME ANY LONGER)

TO DETECT A COLLISION, A NODE MUST RECEIVE THE SIGNAL IN TIME.

SO TO MAKE SURE THAT IT ARRIVES IN TIME, THE FRAME LENGTH MUST BE TWICE THE PROPAGATION DELAY.

FORMULAS:

- MINIMUM FRAME TRANSMISSION TIME:

$$2 \cdot t_{\text{PROPAGATION}}$$

- MINIMUM FRAME SIZE:

$$b \cdot 2 \cdot t_{\text{PROPAGATION}}$$

- EFFICIENCY:

$$\frac{1}{1 + \frac{5 \cdot t_{\text{PROPAGATION}}}{t_{\text{TRANSMISSION}}}}$$

TCP FORMULAS:

- AVERAGE WINDOW SIZE:

$$\frac{3}{4} \cdot \text{WINDOW SIZE}$$

- AVERAGE TCP THROUGHPUT:

$$\frac{3}{4} \cdot \frac{\text{WINDOW SIZE}}{\text{RTT}}$$

LINK-STATE ROUTING ALGORITHM

THE NETWORK TOPOLOGY AND LINK COSTS ARE ALREADY KNOWN.

THIS IS DONE BY HAVING ALL NODES SEND INFO ABOUT THEIR ATTACHED LINKS.

YOU JUST ADD THE ROUTER FOR WHICH YOU HAVE THE CLOSEST PATH TO.

SUBNETTING

ADDRESS SPACES

192.168.150.0/24 IS AN ADDRESS SPACE. ALL IP ADDRESSES OF THIS PARTICULAR SUBNET HAVE THE FIRST 24 BITS AS PREFIX.

EACH IP ADDRESS IS MADE OF 4 BYTES (32 BITS). SO THE LAST 32 − 24 = 8 BITS ARE VARIABLE.

SO IN THIS CASE, WE HAVE 2^8 ADDRESSES IN THE SUBNET.

TOTAL NUMBER OF HOSTS

2 TO THE POWER OF (32 - MASK LENGTH) - 2

⇓

$2^8 - 2$

BROADCAST ADDRESS
AND
SUBNET ADDRESS

SUBNET ADDRESS

FIRST ADDRESS OF THE SUBNET

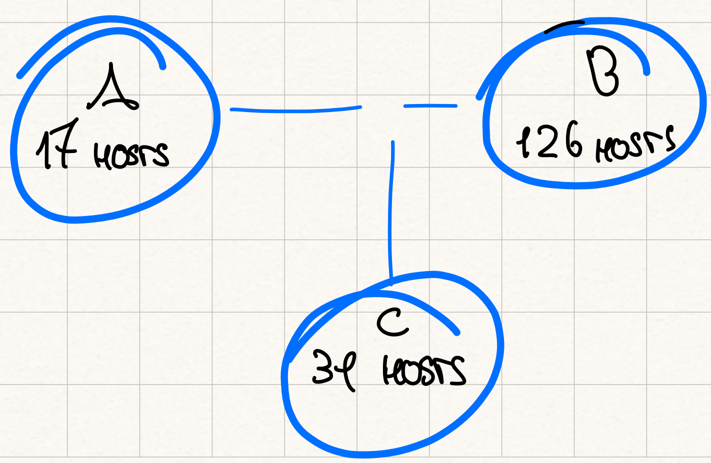
PREVIOUS SUBNET BROADCAST ADDRESS + 1

BROADCAST ADDRESS

LAST ADDRESS OF THE SUBNET

ES:

172.24.188.0/23



THE SUBNETS GO AS FOLLOWS:

B → SUBNET ADDRESS = 172.24.188.0/25

126 HOST

THE /25 MASK IS BECAUSE WE NEED AT LEAST 7 BITS TO ADDRESS 126 HOSTS.

$2^7 = 128$, $128 - 2 = 126$ ADDRESSES.

BROADCAST AND BASE ADDRESS

$2^7 - 1$

BROADCAST ADDRESS = 172.24.188.127

C → SUBNET ADDRESS = 172.24.188.128/26

62 HOST

/26 → 32-6, BECAUSE 6 BITS CAN FIT 64-2 ADDRESSES, 31 < 62.

128+64-1

BROADCAST ADDRESS = 172.24.188.191

A → SUBNET ADDRESS = 172.24.188.192/27

30 HOST

128+64+32-1

BROADCAST ADDRESS = 172.24.188.223