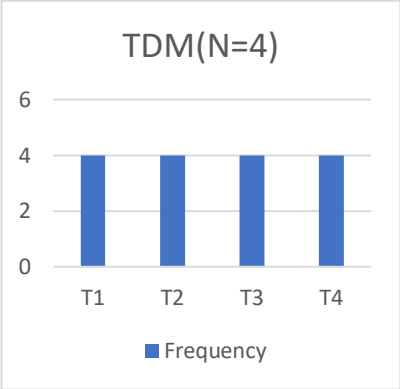
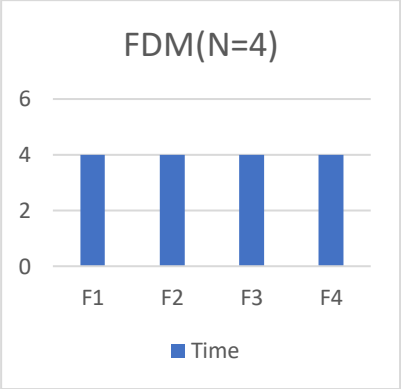
Sheet5

Part1: Static channel allocation

1. For the two static channel allocation techniques FDM and TDM answer the following
   a. Draw and show how the channel can be shared for N=4 stations evenly.





   b. Show how the number of joining stations can affect the performance of these two techniques.

Number of joining stations N	TDM	FDM
N <4	Wasted Time	Wasted Frequency (bandwidth)
N=4	Most efficient if all want to send at the same time.	Most efficient if all want to send at the same time.
N >4	Cannot work for N>4	Cannot work for N>4

2. Suppose a TDM channel allocation technique is used in a channel while the frame transmission time = 2 ms, the propagation delay = 2 ms and the channel bandwidth = 6 Mbps.
   a. Find the channel efficiency

Efficiency= $\eta = \frac{useful\ time}{total\ time} = \frac{T_t}{T_t+T_p} = \frac{2}{2+2} = 50\%$

   b. Find the effective bandwidth of the channel.

Th= η*B=0.50*6M=3 Mbps

   c. If number of stations sharing this channel is N=200 stations, what is the maximum transmission rate of each station.

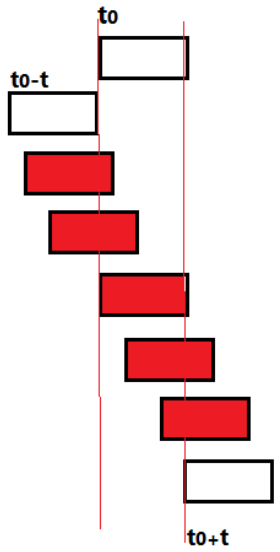
Max_trans_rate_per_station*200= 3Mbps
Max_trans_rate_per_station=15Kbps

3. In which situation is TDM with polling considered an enhancement for ordinary TDM and in what situation it is considered not.

Number of joining stations N	TDM with polling
N is moderate and all of them want to send	Low efficiency as there is a high overhead of the contention window.
N is moderate and few of them want to send	Most efficient.
N is very large number	Very low efficiency as the contention window overhead is large.

Part2: Pure ALOHA and Slotted ALOHA

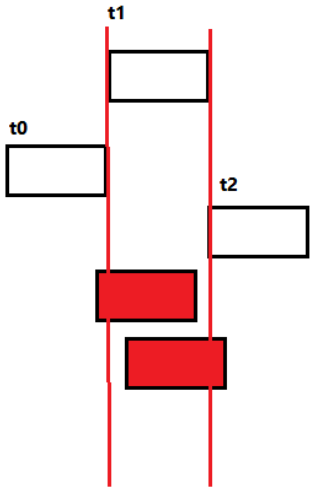
4. Consider the pure ALOHA channel allocation technique and answer the following :
    a. Is it a collision avoidance or collision detection technique? If it is a collision detection technique how it reacts in case of a collision?
    Collision detection: it detects the collision if there isn't ack received.
    On detection of any collision, the sender waits for random time and resends again.
    b. What is the vulnerability period for this technique?
    The vulnerability time is 2t , if the frame time is constant t.



contention time= 2t

c. Given that Probability (k Packets are generated in t frame time) = $(TG)^K * e^{-GT} / !K$
get the maximum throughput of this technique.
The maximum throughput (efficiency) S= rate of transmission * probability of zero collision.
S=G* (probability that no other packet is generated during this transmission)
S=G*($(TG)^K * e^{-GT} / !K$) when k=0, and T=2t.
Get the first derivative =0
Smax=0.18

5. Repeat question 4 for slotted ALOHA technique.
   a. Is it a collision avoidance or collision detection technique? If it is a collision detection technique how it reacts in case of a collision?
   Collision detection: it detects the collision if there isn't ack received.
   On detection of any collision, the sender waits for random number (r) and resends at (r*t), where t is the time slot .
   b. What is the vulnerability period for this technique?
   The vulnerability time is t , given that the time slot= t.



contention time= t

c. Given that Probability (k Packets are generated in t frame time) = $(TG)^K * e^{-GT} / !K$
get the maximum throughput of this technique.
The maximum throughput (efficiency) S = rate of transmission * probability of zero collision.
S=G* (probability that no other packet is generated during this transmission)
S=G*($(TG)^K * e^{-GT} / !K$) when k=0, and T=t.
Get the first derivative =0
Smax=0.36

6. In which situation is Slotted ALOHA considered an enhancement for Pure ALOHA and in what situation it is considered not.

Enhancement	If the number of transmitting stations at the same time is high, so it lowers the probability of collisions
Not enhancement	If the number of transmitting stations is low . in this case stations have to wait for the next transmission time slot (which is here not necessary) and there is also the synchronization overhead .

7. A group of N stations shares 100 Kbps slotted ALOHA channel. Each station outputs a 500 bits frame on an average of 5000 ms even if previous one has not been sent. What is the required value of N stations so that maximum throughput can be reached?

   Maximum throughput (efficiency) η =0.36

   Total Throughput Th= η*B= 0.36 * 100 = 36Kbps

   N_stations*Th_per_station= Total Throughput Th

   Th_per_station = 500 / (5) = 100 bit per second

   N_stations= Total Throughput Th /Th_per_station = (36000)/(100)=360 stations.

8. Repeat 7 for pure ALOHA.

   Maximum throughput (efficiency) η =0.18

   Total Throughput Th= η*B= 0.18 * 100 = 36Kbps

   N_stations*Th_per_station= Total Throughput Th

   Th_per_station = 500 / (5) = 100 bit per second

   N_stations= Total Throughput Th /Th_per_station = (18000)/(100)=180 stations.

9. Consider the delay (time before successful transmission)of pure ALOHA versus slotted ALOHA. Which one is less at low and high number of stations? Explain your answer.

Number of stations	Pure ALOHA	Slotted ALOHA
N is low	Less delay (as number of collisions is low and senders can send immediately and not wait for the next time slot)	More delay (senders will wait for the next time slot)
N is high	More delay (when the probability of collisions increases the protocol efficiency decreases a lot and the senders wait for much longer time until them perform a successful transmission)	Less Delay (the protocols lowers the probability of collisions and becomes more efficient)

Part3: carrier sense multiple access protocols

10. Consider the three CSMA protocols (1-persistent CSMA , p-persistent CSMA and non-Persistent CSMA) and answer the following :
    a. Are they collision free algorithms? If not, in which cases a collision may happen?
    No, if two stations sense the channel is free and starts transmission at the same time.
    b. If a station senses the channel is busy before sending, when it can send its frame? With which probability of sending?

1-persistent CSMA	Once the channel is free (probability =100%)
p-persistent CSMA	Once the channel is free or after random and the channel is free (probability =p)
non-Persistent CSMA	After random time and the channel is free(probability =100%)

11. a) In what way p-persistent CSMA is an improvement of non-persistent CSMA?
    The probability of transmission decreases from 100% to P% . this decreases the collision probability more.

11. b) In what way CSMA/CD is an improvement of non-persistent CSMA?
    The collision detections is faster and less lost time.

12. For how long a station using a channel with CSMA/CD should at least wait before it detects successful transmission operation?

Two propagation delay (2 tp)

13. For a channel with CSMA/CD, if the round trip delay is 4 ms and the channel bandwidth is 20Kbps, calculate the minimum frame length.

Minimum L= 2* Tp * B= (4/1000)*(20 *1000)=80bit.

14. For question 13 if the maximum number of collisions before any first success of frame transmission is 13 ,calculate the channel efficiency

Tt=L/B= 80/(20 * 1000)= 4 ms . check = 2Tp ?

Efficiency η = (Tt)/(C*2*Tp+ Tt+ Tp)

η= 4/(13*4 +4+4)=1/15 = 6% !! .

Part4: collision free protocols

15. In the binary countdown protocol, explain how a lower-numbered station may be starved from sending a packet.
    Stations with high binary address always wins the competition during the contention period. And as long as stations with higher addresses have a lot of data to transmit, lower address stations will have to wait.

16. Consider 3 stations A, B and C that share the same medium and apply bit-map protocol. The following table shows the contention window number where each frame is ready to be sent.

Frames	Arrival windows
A0, A1, A2	0, 3, 7
B0,B1	0,4
C0,C1,C2	3,5,7

Apply the bit-map protocol (show your steps) and find the order of the frames to be sent.

17. Solve the previous question with binary countdown protocol using the following addresses: C=10, B=01, A=00, give the priority to the highest address.

Contention window time step #	Frames transmission sequence (bit map)	Frames transmission sequence (binary count down)
0	A0 then B0	B0
1	--	A0
2	--	--
3	A1 then C0	C0
4	B1	B1
5	C1	C1
6	--	A1
7	A2 then C2	C2
8	--	A2

18. What is the advantage of Binary Countdown protocols over Bit-map ones?
    It has lower number of overhead bits (contention bits), and if we remove the sending address from inside the frame header, then the overhead becomes zero.