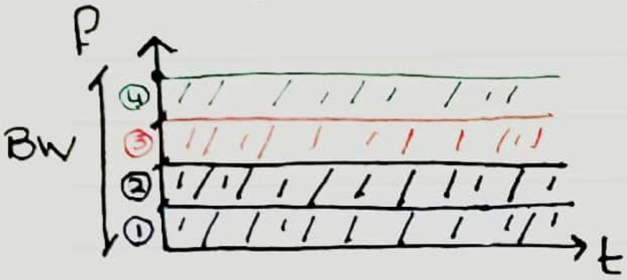
CN Sheet 5

. Static Channel Allocation

1. a) Draw & Show how the Channel Can be Shared For N=4 Stations evenly

FDM



TDM

- each node has its own chunk of the BW (frequency range)
- Can transmit all the time as long it doesn't leave it

- each node has its own recurring chunk of time (time range for sb)
- Can transmit over all the frequency as long as its during its time range

b) Show how the no. of actual Joining Stations affects the Performance of each

- Suppose N frequency / time ranges and K Joining Stations

	K<N	K=N	K>N
TDM	wasted time (N-K) time	* Perfect only if all Stations are always fully using their freq / time range	• Can't work (Some nodes will be denied access)
FDM	wasted frequency (N-K) frequency ranges		

imp

. TDM Rules

$$\eta = \frac{T_t}{T_t + T_p}, \quad B_{eff} = \eta B$$
$$= N B_{node}$$

2. Let $T_t = 2ms$ and $T_p = 2ms$ and $B = 6M$ b/s

a) $\eta = \frac{2}{2+2} = 0.5$

b) $B_{eff} = \eta B = 3M$ b/s

c) $B_{eff} = N.B_{node}$

. Given $N = 200$ Stations
. Wanted is max transmission rate of each node (B_{node})

$$\underbrace{B_{node}}_{} = \frac{B_{eff}}{N} = 15 \text{ Kbps}$$

represents the max transmission rate per node

3. When is TDM with Polling better than ordinary TDM

. Depends on the $\overbrace{\text{no. of Stations}}^{N}$ and their activity

$$\eta = \frac{T_t}{T_{Poll} + T_t + T_p}$$

1. N is too large
   → then T_{Poll} can grow out of control hurting eff. ↓↓
2. N is moderate with high activity
   → then T_{Poll} is wasted as they all want to send anyway!!
3. N is moderate with low activity
   → improvement as $T_{Poll} \ll T_{\text{wasted slots}}$ (most efficient)

. Pure Aloha & Slotted Aloha

4. a) is it a Collision detection or avoidance technique?

→ Collision detection

how does it react to a collision?

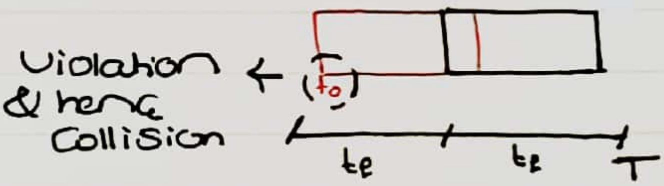
- First, Collision is detected (depending on Channel either by listening for e.g. abnormal voltage or generally, waiting for ackn.)

- Second, it reacts by waiting for a random time then trying again to retransmit.

b) what's the Vulnerability Period of this approach?

- if the frame time is t_f then its $2t_f$

i.e., if a frame ends at $t=T$ then any frame that starts in $(T-2t_f, T]$ Collides with it.



c) Given that the Prob. of K Packets being generated in t frame times is

$$P(K) = \frac{e^{-Gt} \cdot (Gt)^K}{K!}$$

($K \sim \text{Poisson}(\lambda = G)$)

- G is transmissions Per t_f

then what's the maximum throughput.

$$S = G P_{\text{no collision}} = G.P(K=0)_{t=2} = G.e^{-2G}$$

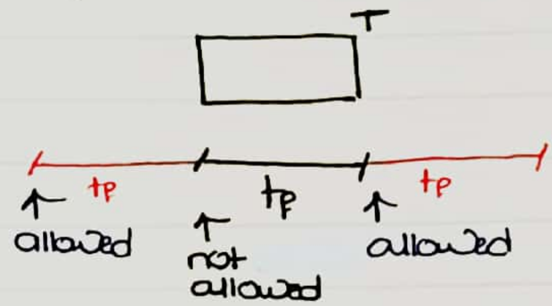
- For S_{max}, Set $\partial G/\partial S = 0$ → $G = 0.5$

$$S_{max} = 0.5e^{-1} = \frac{1}{2e}$$

5. Repeat a, b, c for Slotted Aloha

a) its a collision detection technique
→ upon collision wait random no. of slots then retransmit again

b) the vulneribility period is t_F (where t_F is the frame time)



c) $P(K) = \frac{e^{-Gt} \cdot (Gt)^K}{K!}$

$$S = G \cdot P_{no\,col.} = G \cdot P(K=0)_{t=1} = Ge^{-G}$$

. for S_{max}

$$\partial S / \partial G = 0 \longrightarrow G = 1$$

→ hence,

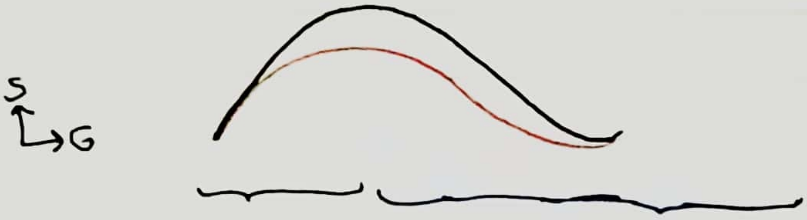
$$S_{max} = \frac{1}{e}$$

6. When is Slotted Aloha better than Pure Aloha?

, Slotted Aloha requires synchronisation of stations
→ if this is easy, we have $S_{Pure} = Ge^{-2G}$ and $S_{Slot} = Ge^{-G}$
. Clearly, $S_{Slot} \geq S_{Pure}$ $\forall G$ and its always better

. However, in Practice each slot in slotted aloha may last more than frame time to account for synchronisation errors (its not easy)

• hence.



• when the no. of transmitting stations is low

• $S_{pure} \simeq S_{slot}$

delay { • but slotting in practice makes slot time redundantly longer

• Not an enhancement

when its high

* improvement as besides the extra slot time it has reduced collisions even more significantly

• enhancement (unless G is too high were both become rubbish)

Aloha Rules

$$B_{eff} = SB = NB_{node}$$

(same as TDM except for S)

• $S_{max} = \begin{cases} \frac{1}{2e} & \text{pure} \\ \frac{1}{e} & \text{slot} \end{cases}$

7. • N stations share B=100 kbps channel for slotted Aloha

• Each node outputs 500 bits over 5000 ms on average ~~(takes retransmissions into account which is a natural)~~ (a)

→ $B_{node} = \frac{500}{5} = 100$ bits

• Find n for max throughput

$$S_{max} . B = N . B_{node}$$

$$\frac{1}{e} . 100K = N . 100$$

$$N = \lfloor 370.3 \rfloor = 370 \text{ nodes}$$

8. Repeat for Pure Aloha

→ Just use $S_{max} = \frac{1}{2e}$ instead

- Yields $N = 180$

9. Compare delay (time before successful transmission) for Pure & Slotted Aloha

G just like 6

N is low ⟷ N is high

N is low:

- Both Pure & Slotted Aloha have similarly low S (and hence prob. of collision)
- But for slotted more delay as
  - → Upon collision have to wait random no. of slots (instead of continuous random time)
  - → Synchronisation may require longer slots compared to frame time.

N is high:

- In this case, Pure Aloha will result in more collisions and hence more delay
- less delay for Slotted Aloha

- We have implicitly assumed that $N \propto G$ (frame transmissions per frame time)

. Carrier Sense Multiple Access

10. Consider 1-Persistent, P-Persistent & non-Persis. CSMA

a) Are they Collision free algorithms?

→ No

→ Collision are Possible when

- Link is too long

- in case of Perfect Sensing ($T_p \downarrow$)

→ only Possible when two stations sense free & transmit in same time

b) if station senses busy channel when can it send

1-Persistent	Non-Persistent	P-Persistent
once its free (keep listening)	after random time & its free	. in the next slot & its free or after random slots & its free
. it will then send with Prob. $=1$	. it will then send with Prob. $=1$	.... with Prob $= P$

11. How does P-Persistent CSMA improve over non-Persistent CSMA?

- when simultaneous nodes are ready to send a smaller no. of them will attempt to send in P-Persistent (as sending Prob < 1)

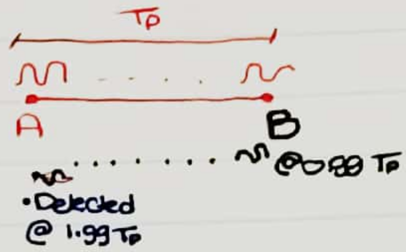
→ hence, the Prob. of a collision decreases

How does CSMA/CD improve over non-persistent CSMA?

→ By checking for collisions during transmission and hence detecting them faster & resulting in less lost time

12. How long should a node wait to detect collision in CSMA/CD?

→ At most $2T_p$



CSMA/CD Rules

→ Minimum transmission time & frame length

$$T_t \geq 2T_p \longleftrightarrow L \geq 2T_pB$$

→ efficiency

$$\eta = \frac{T_t}{\underbrace{2C}_{\text{no. of collisions}}T_p + T_t + T_p}$$

- maximized when $P = \frac{1}{n}$
- $C = e$
- $P(K) = {}^nC_K \cdot P^K (1-P)^{n-K}$ (K nodes try to..)

13. CSMA/CD where $\underbrace{2T_p}_{\text{roundtrip}} = 4\,ms$ and $B = 20\,Kbps$ find L_{min}

$$\Rightarrow L_{min} = 2T_pB = \frac{4}{1000} \times 20 \times 1000$$

$$= 80 \text{ bit}$$

14. if max no. of collisions before succ. transm. is 13 $(C=13)$, find η

$T_t = L/B = 4\,ms$ 6

$$\eta = \frac{4}{2 \times 13 \times 2 + 4 + 2} = 6.7\%$$

. Collision free Protocols

15. Explain how Starvation can occur for binary Countdown?

- Consider N = 16 (address is 4 bits)

→ Consider if the Station 1111 has an ∞ Supply of frames to send

→ it will never give up in the Period (all 1s)

- every other node has a 0 in its address and hence will give up at some point

* Thus, only that Node will get the chance to transmit everytime (the rest will be Starved forever)

16. Given 3 Stations A, B, C

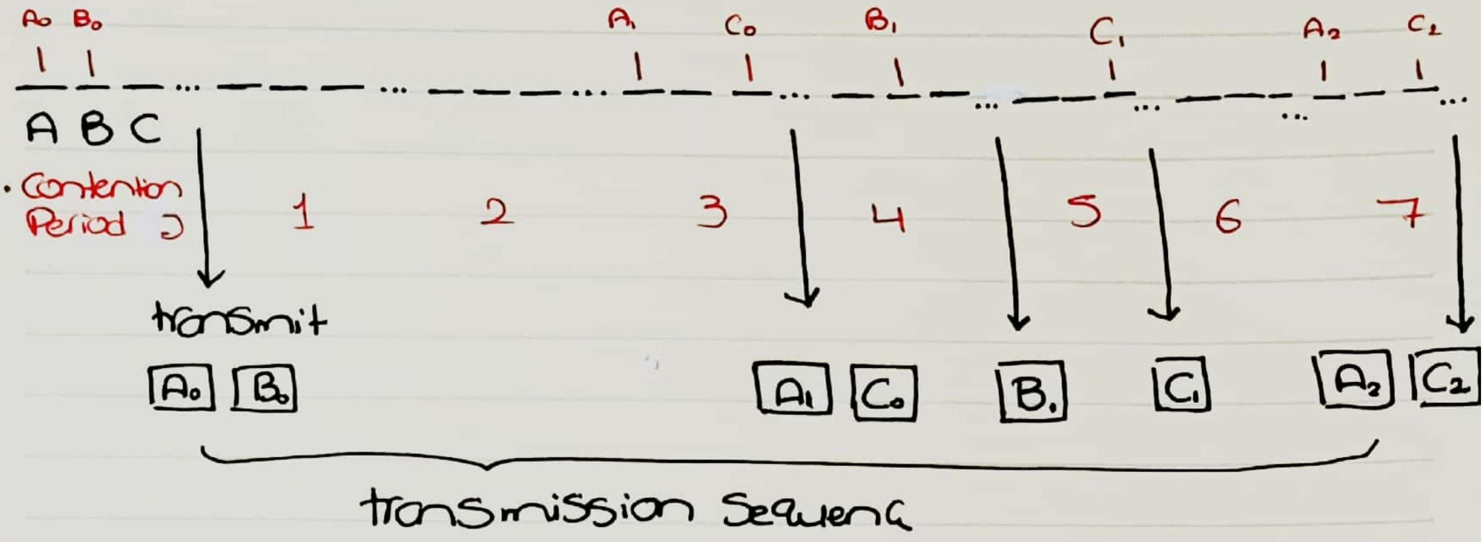
→ A will want to send A0, A1, A2 in Contention Periods 0, 3, 7

→ B will want to send B0, B1 in Contention Periods 0, 4

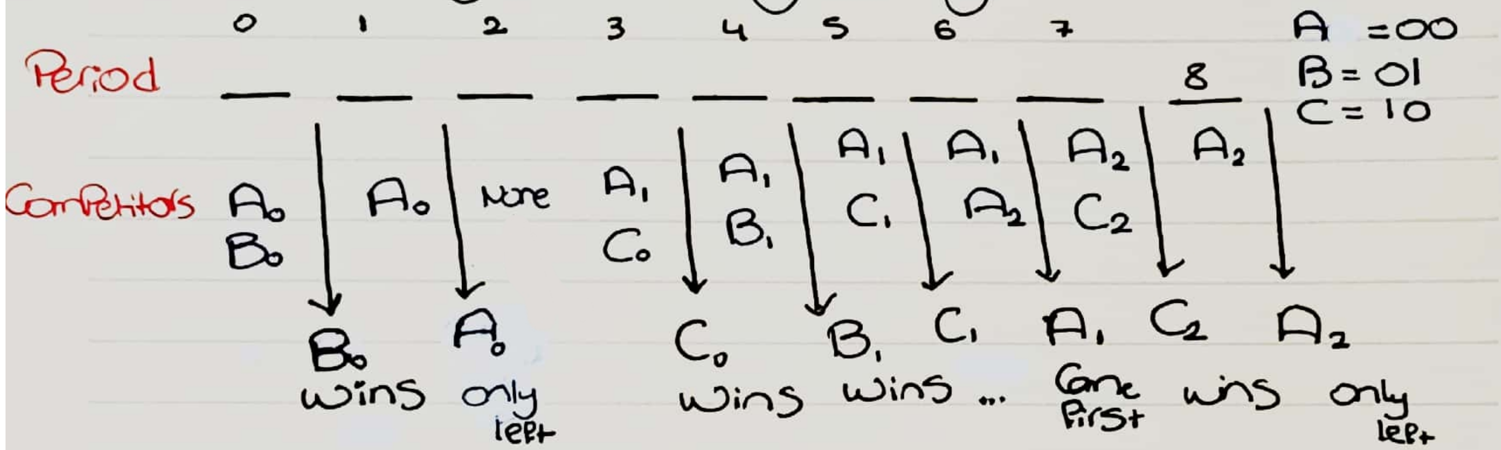
→ C will want to send C0, C1, C2 in Contention windows 3, 5, 7

- So we have 8 Contention windows (and correspond. transmission windows)

• Denote Contention Period as _ _ _ and transmission Period as... (for now)



17. Solve again using binary Countdown



• Note that each Contention Period is 3 Slots (no. of bits) and each Corresponds to only 1 transmission Slot. (here we didn't do it on the bit level, we know larger address wins)

• nodes that lose try again in the next Cont. Period

18. Advantage of binary Countdown over bitmap?

→ higher η in the worst case $\frac{L}{L+\log_2 N} > \frac{L}{L+N}$

• if the address is Part of the frame anyway then $\eta = 100\%$