1. ALOHA (pure)

(a) What is the vulnerable period of pure Aloha broadcast system with $C = 50$ kbps wireless channel assuming 1000 byte frames.

- Vulnerable Period $= 2T$ where T = frame transmission time. Here $T = 1000 \text{ bytes} / 50 \text{ kbps}$
$= 8000 \text{ bits} / 50 \cdot 10^3 \text{ bits/sec}$
$= 160$ millisecond.

So vulnerable period $= 320$ millisecond.

(b) What is the maximum throughput S of such a channel in kbps?

Maximum throughput in pure Aloha $= \frac{1}{2e}$ of channel capacity $= 0.18 \times$ channel capacity $= 0.18 \times 50$ kbps
$= 9$ kbps.

(2) Slotted Aloha: Consider a slotted Aloha channel with infinite number of users where 10% of the slots are idle.

a) What is the channel load G?
b) What is the throughput S?
c) Is the channel underloaded or overloaded?

(a) 10% of slots idle $\Rightarrow$ frame will be successfully transmitted if sent in those 10% of slots $\Rightarrow$ $P_{succ} = 0.1$. According to theory, $P_{succ} = e^{-G}$.
$\Rightarrow G = -\log_e(P_{succ}) = -\log_e(0.1) = 2.3$

(b) According to theory, $S = P_{succ} \cdot G = G \cdot e^{-G}$

As $G = 2.3$ and $e^{-G} = 0.1 \Rightarrow 2.3 \times 0.1 \Rightarrow 0.23$.

(c) Since $G > 1$, the channel is overloaded.

(3)

A pure Aloha network transmits 200-bit frames on a shared channel of 200 kbps. What is the throughput if the system (all stations together) produces a) 1000 frames per second, b) 500 frames per second and c) 250 frames per second.

Ans

The frame transmission time is 200/200 kbps = 1 ms.

a) If system creates 1000 frames per second, this is 1 frame per millisecond so load $G = 1$. In this case, throughput $S = G \cdot e^{-2G} = 1 \cdot \frac{1}{e^2} = 0.135$. This means throughput = 13.5% of 1000 frames = 135 frames. So out of 1000 frames only 135 frames can survive.

b) $G = \frac{1}{2}$, $S = \frac{1}{2} e^{-1} = 0.184$. This means $500 \times 0.184 = 92$ frames out of 500.

c) $G = \frac{1}{4}$, $S = \frac{1}{4} e^{-\frac{1}{2}} = 0.152$. This means $250 \times 0.152 = 38$ frames out of 250.

(4) Same problem with slotted Aloha instead of Aloha.

a) $G = 1$, $S = G \cdot e^{-G} = 1 \cdot e^{-1} = 0.368$. This means $1000 \times 0.368 = 368$ frames out of 1000.

b) $G = \frac{1}{2}$, $S = \frac{1}{2} e^{-\frac{1}{2}} = 0.303$. This means $500 \times 0.303 = 151$ frames of 500.

c) $G = \frac{1}{4}$, $S = \frac{1}{4} e^{-\frac{1}{4}} = 0.195$, this means $250 \times 0.195 = 49$ frames of 250.

(5) A network using CSMA/CD has a bandwidth of 10 Mbps. If maximum propagation time is 25.6 μs, what is the minimum frame size?

$2T = 2 \times 25.6 = 51.2$ μs. The min frame size = 10 Mbps × 51.2 μs = 512 bits or 64 bytes. This is actually min. frame size of Ethernet.

Instead of saying 25.6 μs directly one may say: a cable of 2500 m with signal speed of the cable 97.65625 m/μs. This also gives $T = \frac{2500}{97.65625} = 25.6$ μs

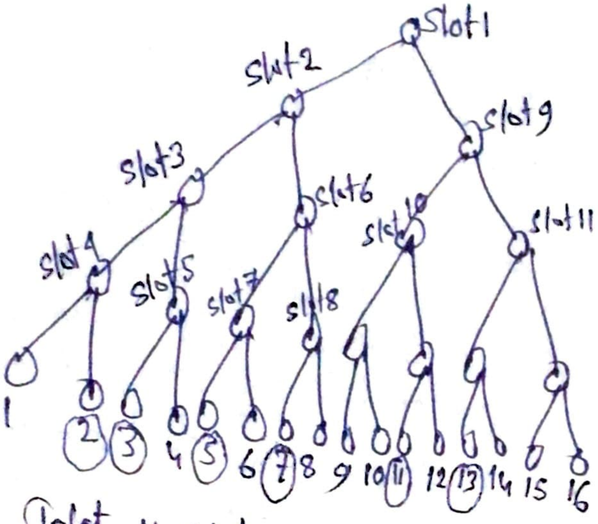
(6) Consider a CSMA/CD running at 1 Gbps with a frame size of 625 bytes. The signal speed is 200 000 km/sec. What is the max cable length?

⇒ frame transmission time = $\frac{625 \times 8}{10^9}$ sec. ~~Length of cable~~ = $\frac{625 \times 8}{10^9} \cdot 2 \times 10^5$ km = 1[illegible]

max cable length = 500 m.

Adaptive Tree walk

① Sixteen stations numbered 1 through 16 are contending for the use of a shared channel by using adaptive tree walk protocol. If all the stations whose addresses are prime numbers suddenly become ready at once how many bit slots are needed to resolve the contention?



Slot 1 : 2, 3, 5, 7, 11, 13
2 : 2, 3, 5, 7
3 : 2, 3
4 : 2
5 : 3
6 : 5, 7
7 : 5
8 : 7
9 : 11, 13
10 : 11
11 : 13

Total 11 slots are needed.

Basic bit map protocol

② How long does a station s has to wait in the worse case before it can start transmitting its frame over a LAN that uses the basic-bit map protocol?

Ans: Assume that each frame is d-bits long. worse case: all stations want to send and s is the highest numbered station. The frame arrives at the MAC layer of station s just after the current contention window starts: wait time is — N bits contention slot + (N-1)d (transmission time of frames of all other stations: N + (N-1)d.

Another worse-case: the frame arrives at the MAC layer of station S just after its current contention slot passed. In this case - it has to wait (N-1)d for the current sequence of frames (every other station has frame to send) + N till contention period of next contention window + (N-1)d (transmission of frame by all other station in the next window) = (N-1)d + N + (N-1)d.

Binary Countdown (Mok and Ward)

(3) A LAN uses Mok and Ward's version of binary countdown protocol. At a certain instant the ten stations have the virtual station numbers 8, 2, 4, 5, 1, 7, 3, 6, 9 and 0. The next three stations to send are 8, 6 and 8 in that order. What are the new station numbers after all three have finished their transmission?

Ans: Let us denote the identities of the 10 stations as A, B, C, D, E, F, G, H, I, and J. At the instant A is in 8th in line, described by the problem, B is in 2nd and so on. When A sends, it becomes 0 and all stations numbered 0-7 are increased by 1.

A	B	C	D	E	F	G	H	I	J
8	2	4	5	1	7	3	6	9	0

After A sends:

0	3	5	6	2	8	4	7	9	1

~~After A~~ Now station D is numbered 6. After D sends, 6 will become 0 and all 0-5 will increased by 1.

1	4	6	0	3	8	5	7	9	2

Now station E is 3. After E sends, 3 will become 0 and all 0-2 will increased by 1.

2	4	6	1	0	8	5	7	9	3
A	B	C	D	E	F	G	H	I	J

⇒ A packet is split into 10 frames, each of which has an 80% chance of arriving undamaged. If no error control is done, how many times the message needs to be sent to the entire packet through?

Sol. packet → 10 frames, each has prob .8 for success. P (success for whole packet)

$= (.8)^{10} = p = 0.107$

$E = \sum_{i=1}^{\infty} i p (1-p)^{i-1} = p \sum_{i=1}^{\infty} i (1-p)^{i-1}$

$= p \cdot \frac{1}{\{1-(1-p)\}^2} = \frac{1}{p} = \frac{1}{0.107} = 9.3.$

⇒ A large population of Aloha users manage to generate 50 request/sec including both new and retransmission requests. Time is slotted in units of 40 msec. What is the chance of success on the first attempt?

Sol: The channel load $G = 50 \times 40 \times 10^{-3} = 2$ request/slot

In one slot, k requests happen with probability $P(k) = \frac{G^k e^{-G}}{k!}$. First attempt succeed with probability = P (no other request (new + retransmission) occurs within the first slot] $= P(0) = e^{-G} = e^{-2} = 0.135$.

= In a CSMA/CD network with a data rate of 10 mbps, the minimum frame size is found to 512 bits for the correct operation of collision detection mechanism. What should be the minimum frame size if we increase the data rate to 100 mbps?

Sol: Frame transmission time = $2 \times T$

= minimum frame size / data rate = 512 bits / 10 mbps

= 51.2 milliseconds. Minimum frame size = frame transmission time × data rate

= $\underset{\text{millisecond}}{51.2} \times \underset{\text{mbps}}{100}$ = 5120 bits.