181105016

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TUTORIAL 6

1. Frames arrive randomly at a 100-Mbps channel for transmission. If the channel is busy when a frame arrives, it waits its turn in a queue. Frame length is exponentially distributed with a mean of 10,000 bits/frame. For each of the following frame arrival rates, give the delay experienced by the average frame, including both queueing time and transmission time.

(a) 90 frames/sec.

(b) 900 frames/sec.

(c) 9000 frames/sec.

$$T = \frac{1}{(\mu C - \lambda)}$$

Where,
"T" is the mean time delay
"μ" is the mean frame length
"C" is the channel capacity
"λ" is the frame arrival rate

(a)

$$T = \frac{1}{(10^{-4} \times 10^{8} - 90)}$$
$$= \frac{1}{(10^{4} - 90)}$$
$$= \frac{1}{(10000 - 90)}$$
$$= \frac{1}{9910}$$
$$= 1.009 \times 10^{-4}$$
$$= 0.1 \times 10^{-3}$$

Therefore, the mean time delay experienced by 90 frames/ sec is 0.1msec.

(b)

$$T = \frac{1}{(10^{-4} \times 10^{8} - 900)}$$
$$= \frac{1}{(10^{4} - 900)}$$
$$= \frac{1}{(10000 - 900)}$$
$$= \frac{1}{9100}$$
$$= 1.099 \times 10^{-4}$$
$$= 1.100 \times 10^{-4}$$
$$= 0.11 \times 10^{-3}$$

Therefore, the mean time delay experienced by 900 frames/ sec is 0.11msec.

(c)
$$T = \frac{1}{\left(10^{-4} \times 10^{8} - 9000\right)}$$
$$= \frac{1}{\left(10^{4} - 9000\right)}$$
$$= \frac{1}{(1000)}$$
$$= 0.001$$
$$= 1 \times 10^{-3}$$

Therefore, the mean time delay experienced by 9000 frames/ sec is 1msec.

2. A group of N stations share a 56-kbps pure ALOHA channel. Each station outputs a 1000-bit frame on average once every 100 sec, even if the previous one has not yet been sent (e.g., the stations can buffer outgoing frames). What is the maximum value of N?

The required data rate is N * (1000 bits per packet) * (1 packet/100 seconds) = 10 N bps

With unslotted aloha, the available data rate is 0.184 * 56,000 bps = 10,300 bps

Rate required = rate available => 10 N = 10300 => N <= 1030 stations.

3. Consider the delay of pure ALOHA versus slotted ALOHA at low load. Which one is less? Explain your answer.

Statistically pure ALOHA is supposed to be less efficient than slotted ALOHA, that means, at normal load or when collisions occur in a contention channel.

However, if the load and therefore the collision rate is low, then pure ALOHA is supposed to be as efficient as slotted ALOHA (statistically). But if we consider the delay of sending the packet in a slotted time as in the slotted ALOHA protocol, then we can say that slotted ALOHA's delay is more than the one in pure ALOHA protocol, which send the packet immediately.

4. A large population of ALOHA users manages to generate 50 requests/sec, including both originals and retransmissions. Time is slotted in units of 40 msec.

(a) What is the chance of success on the first attempt?

(b) What is the probability of exactly k collisions and then a success?

(c) What is the expected number of transmission attempts needed?

The channel traffic load rate G= $50 \times (40 \times 10^{-3}) = 2$ requests/slots. In one slot, k requests happen with the probability $P(k) = e^{-G} . (G)^k / k!$

(a) First attempt succeeds with the probability
Pr [no other request (new or retransmission) occurs within the first slot] = $P_0 = e^{-G} = e^{-2} = 0.135$

(b) If assuming that things happening in different slots are independent, the probability is
P(success after k collisions) = $[\ P(\text{failure})\ ]^k \times P(\text{success}) = (1 - e^{-G})^k e^{-G} = (1 - e^{-2})^k e^{-2} = 0.135 \times 0.865^k$

(c) The expected number of transmissions needed
E = traffic load/ throughput = $G/S = G/G\, e^{-G} = e^{G} = 7.4 \approx 8$ transmissions

5. What is the length of a contention slot in CSMA/CD for

(a) a 2-km twin-lead cable (signal propagation speed is 82% of the signal propagation speed in vacuum)?

(b) a 40-km multimode fiber optic cable (signal propagation speed is 65% of the signal propagation speed in vacuum)?

(a) Propagation speed in twin lead = $0.82*3*10^8$ m/s = $2.46*10^8$ m/s
Distance = 2000 m
Contention Period = 2Tp = $(2*2000)/ (2.46*10^8)$ sec = 16.26 μsec

(b) Propagation speed in multimode fiber = $0.65*3*10^8$m/s = $1.95*10^8$m/s
Distance = 40,000 m
Contention Period = $(2*40000)/ (1.95*10^8)$ sec = 410.26 μsec

6. How long does a station, s, have to wait in the worst case before it can start transmitting its frame over a LAN that uses the basic bit-map protocol?

The worst case is when all stations want to send and S is the lowest numbered station. S needs to wait N bit contention period + (N-1)*d bit for transmission of other data frames. The wait time is N + (N-1)*****d.

7. In the binary countdown protocol, explain how a lower-numbered station may be starved from sending a packet.

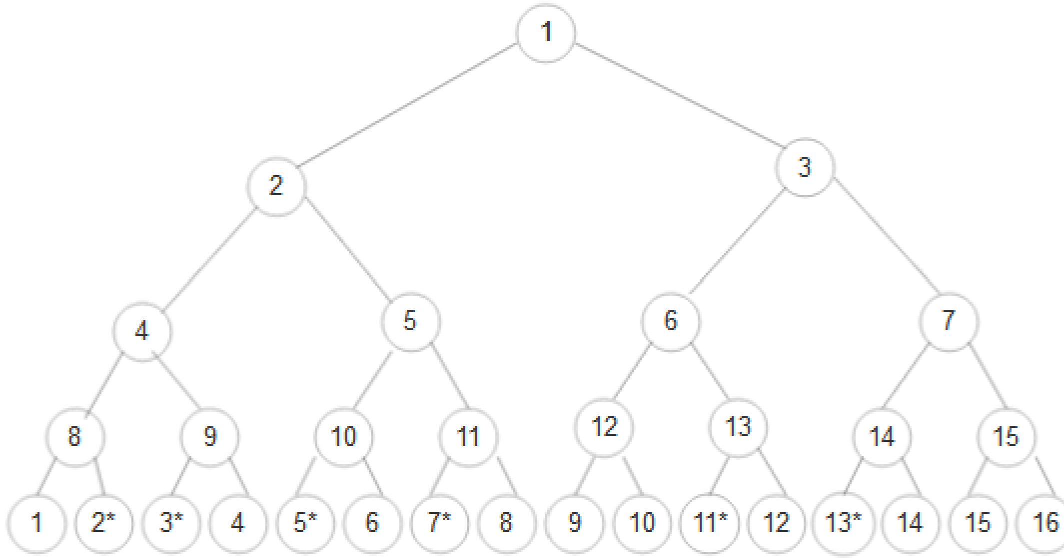
In a binary countdown protocol, each station is assigned a binary address. The binary addresses are bit strings of equal lengths. When a station wants to transmit, it broadcasts its address to all the stations in the channel, one bit at a time starting with the highest order bit. In order to decide which station gets the channel access, the addresses of the stations which are broadcasted are ORed. The higher numbered station gets the channel access.

Therefore, if a lower numbered station is always competing with higher numbered stations, it may be starved from sending a packet.

8. Sixteen stations, numbered 1 through 16, are contending for the use of a shared channel by using the 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?

Stations 2, 3, 5, 7, 11 and 13 want to send:

Slot 1: 2, 3, 5, 7, 11, 13
Slot 2: 2, 3, 5, 7
Slot 3: 11, 13
Slot 4: 2, 3
Slot 5: 5, 7
Slot 6: 11
Slot 7: 13
Slot 8: 2
Slot 9: 3
Slot 10: 5
Slot 11: 7
Slot 12: -
Slot 13: 11
Slot 14: 13
Slot 15: -



Therefore, 13-bit slots are needed.

9. Consider five wireless stations, A, B, C, D, and E. Station A can communicate with all other stations. B can communicate with A, C and E. C can communicate with A, B and D. D can communicate with A, C and E. E can communicate A, D and B.

(a) When A is sending to B, what other communications are possible?

(b) When B is sending to A, what other communications are possible?

(c) When B is sending to C, what other communications are possible?

(a) Since all stations will see A's packet, it will interfere with receipt of any other packet by any other station. So, no other communication is possible in this case.

(b) Although B's packet will not be seen by D, other nodes, e.g., E, or C, cannot send to D because the packets from these nodes will interfere with the packets from B at A. Therefore, other communications are not possible at the same time.

(c) B's packet will be seen by E, A and C, but not by D. Thus, E can send to D at the same time.