[Winter 2010 CSE3213 Communication Networks](#)
Assignment # 5
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Review sections 6.1-6.4 Garcia before attempting the assignment.

1. Suppose that the ALOHA protocol is used to share a 56 kbps satellite channel. Suppose that frames are 1000 bits long. Find the maximum throughput of the system in frames/second.

Solution:
Maximum throughput for ALOHA = 0.184

Maximum throughput in frames/sec = (56000 bits/sec) x (1 frame/1000 bits) x 0.184 = 10.304

The maximum throughput is approximately 10 frames/sec.

2**.** Let G be the total rate at which frames are transmitted in a slotted ALOHA system. What proportion of slots goes empty in this system? What proportion of slots go empty when the system is operating at its maximum throughput?

Solution:

Proportion of empty slots = P[0 transmission] = $[G^0/0!]e^{-G} = e^{-G}$

Maximum throughput = 0.368; $G_{mt} = 1$

Proportion of empty slots at maximum throughput = $e^{-1} = 0.368$

Any attempt to decrease the proportion of empty slots below e^{-1} is counterproductive as this action will push the throughput below its maximum value.

3**.** In a LAN, which MAC protocol has a higher efficiency: ALOHA or CSMA-CD? What about in a WAN?

Solution:
The maximum efficiency achieved by the Slotted ALOHA is 0.368. The efficiency of CSMA-CD is given by 1/(1 + 6.4a), and is sensitive to $a = t_{prop}R/L$, the ratio between delay-bandwidth product and frame length.
In a LAN environment, the end-to-end distance is around 100m and the transmission rates are typically 10Mbps, 100Mbps and 1Gbps (See Table 6.1). An Ethernet frame has a maximum length of 1500 bytes = 12,000 bits.
The table shows the efficiency of CSMA-CD at various transmission rates. Assume L = 12,000 bits and propagation speed of 3×10^8.

	a	Efficiency
10 Mbps	3×10^{-4}	0.998
100 Mbps	3×10^{-3}	0.981
1 Gbps	3×10^{-2}	0.839

Note however that if shorter frame sizes predominate, e.g. 64 byte frames, then a increases by a factor of about 20. According to the above formula the efficiency of CSMA-CD at 1 Gbps then drops to about 0.7. The situation however is worse in that the minimum frame size at 1 Gbps needs to be extended to 512 bytes, as discussed in page 436 of the text.

In a WAN environment d is larger. Assuming 100 Km, a is larger by a factor of 10^3 resulting in an efficiency of 0.36, 0.05, and 0.005 respectively for 10 Mbps, 100 Mbps, and 1 Gbps transmission rates. In the case of 10 Mbps transmission rate the efficiency of CSMA-CD is close to the efficiency of ALOHA but in the other two cases it is much less than ALOHA.

4. M terminals are attached by a dedicated pair of lines to a hub in a star topology. The distance from each terminal to the hub is d meters, the speed of the transmission lines is R bits/second, all frames are of length 12500 bytes, and the signal propagates on the line at a speed of $2.5 (10^8)$ meters/second. For the four combinations of the following parameters {d = 25 meters or d = 2500 meters; R = 10 Mbps or R = 10 Gbps}, compare the maximum network throughput achievable when the hub is implementing: Slotted ALOHA; CSMA/CD.

Solution:

L = 12500 x 8 bits, $t_{prop} = d / (2.5 \times 10^8$ meters/sec), $a = t_{prop} R/L$

Values for a:

R/d

	2x25	2x2500
1.00E+07	2E-05	2E-03
1.00E+10	2E-02	2E+00

Maximum Throughput for Slotted ALOHA:

R/d

	2x25	2x2500
1.00E+07	0.367879	0.367879
1.00E+10	0.367879	0.367879

Maximum throughput for CSMA-CD:

R/d

	2x25	2x2500
1.00E+07	0.999872	0.98736
1.00E+10	0.886525	0.07246

5. A token-ring LAN network interconnects M stations using a star topology in the following way. All the input and output lines of the token-ring station interfaces are connected to a cabinet where the actual ring is placed. Suppose that the distance from each station to the cabinet is 100 meters and that the ring latency per station is eight bits. Assume that frames are 1250 bytes and that the ring speed is 25 Mbps.

Solutions follow questions:

d = 100 m from each station to the cabinet

v = 2 x 10^8 m/sec

b = 8 bits

L = 1250 bytes = 10000 bits

R = 25 Mbps

$$X = \frac{10000}{25M} = 4 \times 10^{-4} \text{ sec}$$

$$\tau' = \frac{M2d}{v} + \frac{M8}{R} = \frac{M200}{2 \times 10^8} + \frac{M8}{25 \times 10^6} = 1.32 \times 10^{-6} M$$

$$a' = \frac{\tau'}{X} = \frac{1.32 \times 10^{-6} M}{4 \times 10^{-4}} = 3.3 \times 10^{-3} M$$

a. What is the maximum possible arrival rate that can be supported if stations are allowed to transmit an unlimited number of frames/token?

When all stations are allowed to transmit an unlimited number of frames/token, $\rho_{max} = 1$ and $\rho = \lambda X$.

$$\lambda_{max} = \frac{1}{4 \times 10^{-4}} = 2500 \text{ frames/sec}$$

b. What is the maximum possible arrival rate that can be supported if stations are allowed to transmit 1 frame/token using single-frame operation?

$$\rho_{max} = \frac{1}{1 + a'\left(1 + \frac{1}{M}\right)}$$

$$\lambda_{max} = \frac{1}{1 + (3.3 \times 10^{-3} M)(1 + \frac{1}{M})} \cdot \frac{1}{4 \times 10^{-4}} = \frac{2500}{1.0033 + 0.0033M}$$