Solutions to assignment #6

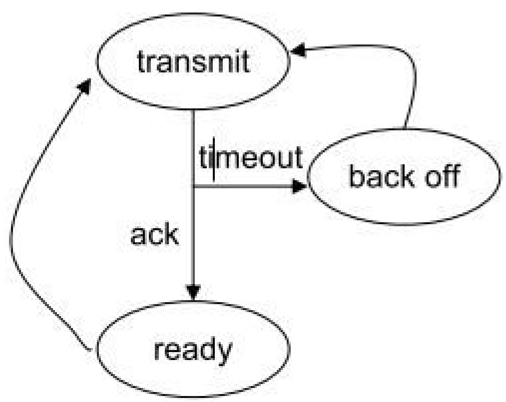
Computer Networks 1

1.

The computers in a LAN are separated by a short distance (typically < 100m) so high speed and reliable communication is possible using a shared broadcast medium. The cost of the medium is negligible and the overall cost is dominated by the cost of the network interface cards in each computer. In addition, the LAN users usually belong to the same group where all users are generally trusted, so broadcast does not pose much security danger. The original reason for avoiding a multiplexer and switch approach to LANs is that a centralized, expensive "box" is required. The availability of Application Specific Integrated Circuits (ASICs) has reduced the cost of switching boxes and made switch-based LANs feasible, and in some environments the dominant approach.

2. With pure ALOHA the usable bandwidth is 0.184 × 56 kbps = 10.3 kbps. Each station requires 10 bps, so N = 10300/10 = 1030 stations.

3.



4. With pure ALOHA, transmission can start instantly. At low load, no collisions are expected so the transmission is likely to be successful. With slotted ALOHA, it has to wait for the next slot. This introduces half a slot time of delay.

5. Each terminal makes one request every 125 sec, for a total load of 50 requests/sec. Hence G = 50/8000 = 1/160.

6. (a) With G = 2 the Poisson law gives a probability of e^{-2}.

(b) $(1 - e^{-G})^k e^{-G} = 0.135 \times 0.865^k$.

(c) The expected number of transmissions is $e^G = 7.4$.

7. For a 1-km cable, the one-way propagation time is 5 μsec, so $2\tau = 10$ μsec. To make CSMA/CD work, it must be impossible to transmit an entire frame in this interval. At 1 Gbps, all frames shorter than 10,000 bits can be completely transmitted in under 10 μsec, so the minimum frame is 10,000 bits or 1250 bytes.

8. Number the acquisition attempts starting at 1. Attempt i is distributed among $2^i - 1$ slots. Thus, the probability of a collision on attempt i is $2^{-(i-1)}$. Theprobability that the first k − 1 attempts fail, followed by a success on round k is:

$$P_k = (1 - 2^{-(k-1)}) \prod_{i=1}^{k-1} 2^{-(i-1)}$$

which can be simplified to

$$P_k = (1 - 2^{-(k-1)})\, 2^{-(k-1)(k-2)/2}$$

9. 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 rate. Assume L = 12,000 bits and propagation speed of 3×10^8.

	a	Efficiency
10 Mbps	3 x 10 -4	0.998
100 Mbps	3 x 10 -3	0.981
1 Gbps	3 x 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.

10. Refer to your class notes.

11.

$L = 12500 \times 8$ 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

12.

a. The distance from each terminal to the hub is d meters, so the total distance around the ring is then M2d. Assuming single frame transmission token reinsertion, then

X_{eff} = token transmission time + frame transmission time + ring latency

$$= \frac{L_{token} + L_{frame}}{R} + M\left(\frac{2d}{v} + \frac{b}{R}\right)$$

b. The maximum throughput occurs when all stations transmit k frames per token. After completing the transmission of k frames, each station waits one ring latency time and then transmits a free token into the ring.

$\tau = M\left(\frac{2d}{v} + \frac{b}{R}\right)$ is the amount time spent in passing the token around the ring.

Calculation:

i. d = 25 m, R = 10 Mbps

τ = 0.125 ms, X_{frame} = 10 ms, X_{token} = 2.4μsec,

$X_{eff} = \frac{(3+12500)\times 8}{10M} + 125\left(\frac{2\times 25}{2.5\times 10^8} + \frac{8}{10M}\right)$ = 10.1 ms

$$\rho_{max} \approx \frac{1}{1+\frac{.125}{10k}} \approx 99\%$$

X_{token} and τ are negligible.

ii. d = 25 m, R = 10 Gbps

τ = 25.1 μsec, X_{frame} = 10 μsec, X_{token} = 0.0024 μsec,

X_{eff} = 35.1 μsec

$$\rho_{max} \approx \frac{1}{1+\frac{25.1}{10k}} = \frac{1}{1+\frac{2.5}{k}}$$

ρ_{max} = 28% for k =1 and improves as k increases.

iii. d = 2500 m, R = 10 Mbps

τ = 2.6 ms, X_{frame} = 10 ms, X_{token} = 2.4 μsec,

X_{eff} = 12.6 ms

$$\rho_{max} \approx \frac{1}{1+\frac{2.6}{10k}} = \frac{1}{1+\frac{0.26}{k}}$$

ρ_{max} = 79% for k = 1 and improves as k increases.

iv. d = 2500 m, R = 10 Gbps

τ = 2.5 ms, X_{frame} = 10 μsec, X_{token} = 0.0024 μsec,

X_{eff} = 2.51 ms

$$\rho_{max} \approx \frac{1}{1+\frac{2.5}{.010k}} = \frac{1}{1+\frac{250}{k}}$$

ρ_{max} = 0.40%, nearly zero.

13.

A frame contains 512 bits. The bit error rate is $p = 10^{-7}$. The probability of all 512 of them surviving correctly is $(1 - p)^{512}$, which is about 0.9999488.The fraction damaged is thus about 5×10^{-5}. The number of frames/sec is 11×10^6 /512 or about 21,484. Multiplying these two numbers together, we get about 1 damaged frame per second.

14.

Uncompressed video has a constant bit rate. Each frame has the samenumber of pixels as the previous frame. Thus, it is possible to compute very accurately how much bandwidth will be needed and when. Consequently, constant bit rate service is the best choice.

15.

No. The encoding is only 80% efficient. It takes 10 bits of transmitted data to represent 8 bits of actual data. In one second, 1250 megabits are transmitted, which means 125 million codewords. Each codeword represents 8 data bits, so the true data rate is indeed 1000 megabits/sec.

16.

The difference between a hub and a switch is that in the hub frame are broadcast to all lines, while in a switch, frames are forwarded to another collision domain only if the destination is in that domain. When 80% of the traffic is local, the switch will only forward 20% of frames to other collision domains, thus increasing the bandwidth available on those domains. If 80% of the traffic is to other collision domains, then the switch forward more traffic to other domains. If there is only one other domain, then the switch forwards almost as much traffic as a hub would and is thus ineffective in containing broadcast traffic. On the other hand, if the switch has multiple broadcast domains, then the amount of traffic forwarded from the switch will be less than that forwarded by a hub.

17 – 22: Refer to your text book (Garcie) chapter 6, wireless networks section.