UNIVERSITY OF CALIFORNIA, LOS ANGELES
CS M117

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Pre-laboratory Homework #2 (Due 10/22)
(HW must be typed)

Section A
Wireless MAC, TCP

1. (1) Are RTS and CTS used with short packets, even if there is a hidden terminal situation?

No. RTS and CTS should not be used with sufficiently-short packets. That is, if the packet is shorter than the RTS, it would be more efficient to simply send the packet and expect occasional collision, even in the face of a hidden terminal situation.

2. (2) Should we still use the Contention Window and Binary Backoff with short packets? Explain?

Yes. Collision can still occur with short packets, so Binary Backoff in conjunction with the Contention Window would be necessary for retransmitting data with fair timing, appropriate to the amount of traffic.

3. (2) Why can a new packet that senses the medium idle go off without using the Contention Window ("direct access if medium is free") ?

If the medium is idle and therefore free to communicate, direct access can be granted to the new packet. Otherwise, using the Contention Window (which is used for retransmitting data anyway) can involve unnecessary delays.

4. (2) Suppose that an 11 Mbps 802.11b LAN is transmitting 64-byte frames back-to-back over a radio channel with a bit error rate of 10^{-7}. How many frames per second will be damaged on average?

64-byte frame = 64*8-bit frame = 512 bits/frame
P(frame damaged) = 1 – P(frame not damaged)
= $1 - (1 - 10^{-7})^{512}$ = 0.000051198692
We send 11 Mbps, or $11 \cdot \frac{10^6}{512}$ = 21484.375 frames per second.
Therefore, 21484.375*P(frame damaged) = 1.1 damaged frames/s

5. <u>(2)</u> Consider the effect of using slow start on a line with a 10-msec round-trip time and no congestion. The receive window is 24 KB and the maximum segment size is 2 KB. How long does it take before the first full window can be sent?

Slow start, with an MSS of 2 KB, begins by sending 2 KB. It continues to send RTTs of 2 segments of 4 KB, 4 segments of 8 KB, 8 segments of 16 KB, and so on. At 16 segments of 32 KB, the receive window is surpassed. Therefore, we go through 4 RTTs for a total of 4*10 msec = 40 msec.

6. <u>(1)</u> Given a channel with an intended capacity of 20 Mbps. The bandwidth of the channel is 3 MHz. What signal-to-noise ratio is required in order to achieve this capacity?

Using Shannon's Capacity Theorem: $C = B \cdot \log_2\left(1 + \frac{S}{N}\right)$

$$20\ Mbps = 3\ MHz \cdot \log_2\left(1 + \frac{S}{N}\right)$$

$$2^{\frac{20}{3}} = 2^{\log_2\left(1+\frac{S}{N}\right)}$$

$$\frac{S}{N} = 101.6 - 1$$

Therefore, the S/N (signal-to-noise ratio) is 100.6.

Section B

Data Transmission over 802.11b Wireless LAN

1) (a) (1) List the three different modes of multipath signal propagation (besides direct signal) and the cause for each of these modes.

(b) (1) What kind of signal reception problems these different modes cause?

a) The three modes of signal propagation are…
 -Reflection, often from surfaces larger than wavelength
 -Diffraction, when waves are obstructed by sharp-edged surfaces
 -Scattering, when objects are smaller than wavelength

b) Reflection is known to cause large-scale fading, while diffraction and scattering can cause small-scale fading. Other problems involve a weakened signal or a dispersed signal.

2) (a) (1) How do multipath signals effect signal reception? This effect limits the transmission rate of wireless channel.

(b) (1) Give relation between transmission rate and this "effect" in part (a).

a) Multipath signals that are time-delayed can cause inter-symbol interference, or distorted signals (with noise or unreliability) that arrive at the receiver with different length and at different times. These interval delays can cause the channel's transmission rate to be held up.

b) $R = \frac{1}{2\tau_d}$

Multipath transmission is inversely-related with transmission rate; as multipath transmission increases, the overall rate drops.

3) (a) (2) How much power you expect to receive if your receiver is at distance d away from the transmitter and the transmitter transmits at frequency f_c. Assume isotropic receiver/transmitter antennas and isotropic free *space* loss. Give path loss in dB.

(b) (1) Assume your WLAN system has transmission power of 15 dBm and the received power must be at least –72 dBm. WLAN radio frequency is 2.4 GHz. Assuming isotropic antennas and no obstructions (i.e. isotropic free space loss), what is the maximum distance you can communicate over.

a) Free space isotropic loss (dB)

$$L_{ISO} = 20 \cdot \log\left(\frac{4\pi f_c d}{c}\right)$$

L_{ISO} is the inverse of power received, as shown in the course reader.

$$P_{received} = P_{transmitted} \cdot \left(\frac{c}{4\pi f_c d}\right)^2$$

b)

$$P_{transmitted} = 15\ dBm$$
$$P_{received} = -72\ dBm$$
$$f_c = 2.4\ GHz$$
$$P_{received} = P_{transmitted} - L_{ISO}$$
$$-72\ dBm = 15 dBm - 20 \cdot \log\left(4\pi \cdot 2.4 \cdot 10^9 \cdot \frac{d}{3 \cdot 10^8}\right)$$
$$10^{\log\left(4\pi \cdot 2.4 \cdot 10^9 \cdot \frac{d}{3 \cdot 10^8}\right)} = 2^{87/20} dBm$$
$$d = 10^{87/20}(3 \cdot 10^8)/(4\pi \cdot 2.4 \cdot 10^9)$$
$$d = 222.69\ m$$

4) (1) What is frequency range of 802.11b Wireless Channel?

2.4 to 2.4835 GHz

5). (2) Multipath fading is maximized when the two beams arrive 180 degrees out of phase. How much of a path difference is required to maximize the fading for a 50-km-long 1-GHz microwave link?

$$\lambda = \frac{c}{f} = \frac{3 \cdot 10^8\ m/s}{1 \cdot 10^9 s^{-1}} = 0.3\ m = 30\ cm$$

The beams are considered out of phase if separated by 15 cm (half of 30 cm), so the path difference is 15 cm.