ECE 2305: Introduction to Communications and Networks

Quiz #3

3:00-3:30 PM, April 10, 2014

Name: Solutions

Box #: _____

Instructions:

- Do not open this quiz until you are instructed to do so.
- This quiz is closed book, but you are permitted to bring one two-sided 8.5" by 11" sheet of notes.
- Calculators are permitted.
- Laptops or other electronic devices with wireless capability are *not* permitted.
- No collaboration is permitted; the WPI academic honesty policy is in effect.
- You have 30 minutes to complete the quiz.
- No partial credit will be awarded for multiple choice problems.
- Please submit your sheet of notes when you turn in your quiz.

Problem	Points	Score
1	15	
2	5	
3	5	
4	10	

Good luck!

1. **Propagation modeling (15 pts total)** Consider the wireless propagation model

$$\text{attenuation(dB)} = 10\log_{10}\left(\frac{(4\pi d)^2}{\lambda_c^2 G_t G_r}\frac{1}{4\sin^2\left(\frac{2\pi h_t h_r}{\lambda_c d}\right)}\right)$$

where λ_c is the carrier wavelength (meters), and G_t and G_r are the absolute transmit and receive antenna gains, respectively, d is the distance between the transmit and receive antennas (meters), and h_t and h_r are the transmit and receive antenna heights, respectively.

(a) 5 pts. What are the implicit assumptions in this wireless propagation model?

This is a line-of-sight propagation model over a flat reflecting surface that causes multipath propagation. The carrier frequency is at least 30 MHz.

(b) 10 pts. Suppose d, G_t, G_r, and λ_c are all fixed but you are allowed to vary h_t and/or h_r (the transmit and receive antenna heights). How should h_t and h_r be selected to minimize the attenuation?

Smallest attenuation occurs when the term $\sin^2\left(\frac{2\pi h_t h_r}{\lambda_c d}\right)$ is largest. Since $\sin^2\left(\frac{2\pi h_t h_r}{\lambda_c d}\right) \le 1$, we need

$\sin^2\left(\frac{2\pi h_t h_r}{\lambda_c d}\right) = 1$ or $\frac{2\pi h_t h_r}{\lambda_c d} = \frac{\pi}{2} + n\pi$, $n = 0, \pm 1, \pm 2, \cdots$

Hence, $\boxed{h_t h_r = \lambda_c \cdot d\left(\frac{n}{2} + \frac{1}{4}\right)}$

The product of antenna heights should be $\frac{2n+1}{4}$ multiple of $\lambda_c \cdot d$.

2. **Shannon Limit (5 pts)** Which channel has a larger Shannon capacity: (a) 20 MHz bandwidth with SNR=10 dB or (b) 40 MHz bandwidth with SNR=6 dB? Explain.

Write Shannon capacity:

$$C = B \cdot \log_2(1+SNR)$$

For a) $10\log_{10}(SNR) = 10dB$

$SNR = 10^1 = 10$

capacity

$C_a = 20 \cdot 10^6 \cdot \log_2(1+10)$

$= 69.2 \cdot 10^6$ bits/sec

For b) $10\log_{10}(SNR) = 6dB$

$SNR = 10^{0.6} \simeq 4$

$C_b = 40 \cdot 10^6 \cdot \log_2(1+4)$

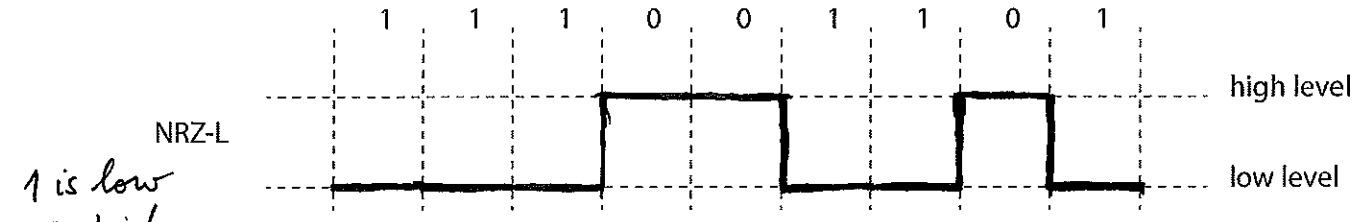
$= 92.9 \cdot 10^6$ bits/sec

The 40MHz channel has higher capacity.

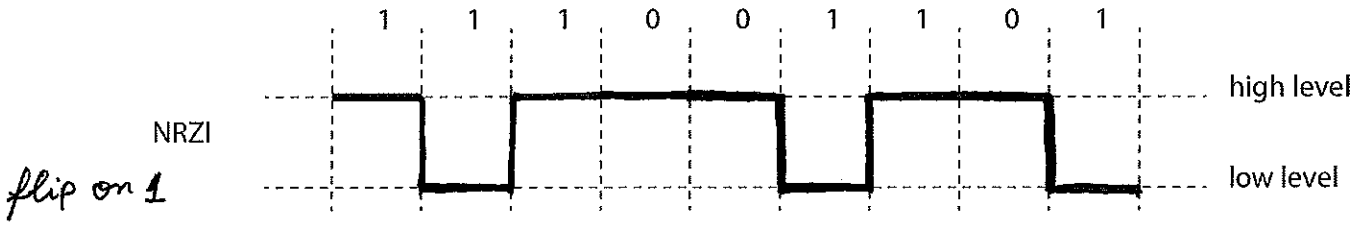
3. **Conditional get with http protocol (5 pts)** In the lab, we saw that the http protocol performs a "conditional get" when requesting an object from the server. What is the reason for including this feature in the http protocol?

A "conditional get" is used to indicate if a resource has been modified when requested again. This is used inorder to not send the same resource to the client on follow-up requests if it hasn't been modified.

4. **NRZ-L versus NRZ-I (10 pts)** Recall the NRZ-L (Nonreturn to Zero Level) and NRZI (Nonreturn to Zero, invert on ones) encoding schemes. Sketch the waveforms for NRZ-L and NRZI-encoded signals corresponding to the bit stream 111001101. Use the figures below to make your sketch neat. For NRZI, the first bit has been already sketched; just sketch the remaining bits.



1 is low
0 is high



flip on 1
Keep same value on 0