KFUPM - COMPUTER ENGINEERING DEPARTMENT

COE-543 – Mobile Computing and Wireless Networking
Assignment 1 – Due Sunday March 23rd, 2008

Chapter 1: Overview of Wireless Networks

Question 1: (20 points) Mobile WiMAX, based on the IEEE802.16e2005 standard, adopts Orthogonal Frequency Division Multiple Access (OFDMA) as the method for providing send and receive traffic services between the basestation and the terminals.

1) Explain *briefly* the basic idea behind OFDMA and how does it provide "scalable access". You may refer to the references listed below.

2) Mobile WiMAX provides in general two types of sub-channels. The first is so called diversity sub-channels where the sub-carriers are allocated "pseudo randomly" across the entire system bandwidth, while the second is referred to as contiguous sub-channels where all sub-carriers belonging to a single sub-channel are physically contiguous in the frequency spectrum. Describe briefly these two sub-channel structures and highlight their expected performance merits.

References:

[1] "Mobile WiMAX – Part I: A Technical Overview and Performance Evaluation," WiMAX Forum, August, 2006 - http://www.wimaxforum.org/technology/downloads/

[2] "WiMAX System Evaluation Methodology," WiMAX Forum, Version 1.7 September 7, 2007 - http://www.wimaxforum.org/technology/downloads/

[3] http://en.wikipedia.org/wiki/OFDMA

[4] IEEE802.16e2005 standard document – http://ieeexplore.ieee.org/iel5/10676/33683/01603394.pdf or later (more up to date versions)

Chapter 2 – Characteristics of Wireless Medium

Question 2: (50 points) The Mobile WiMAX community recommends the usage of the ITU model for modeling multipath for performance evaluation purposes of the Mobile WiMAX system. The model is specified by the following profiles:

Environment	Tap	Channel A			Channel B		
		Relative delay (ns)	Average Power (dB)	RMS (ns)	Relative delay (ns)	Average Power (dB)	RMS (ns)
Indoor office	1	0	0	35	0	0	100
	2	50	-3.0		100	-3.6	
	3	110	-10.0		200	-7.2	
	4	170	-18.0		300	-10.8	
	5	290	-26.0		500	-18.0	
	6	310	-32.0		700	-25.2	
Outdoor to indoor & pedestrian	1	0	0	45	0	0	750
	2	110	-9.7		200	-0.9	
	3	190	-19.2		800	-4.9	
	4	410	-22.8		1200	-8.0	
	5	-	-		2300	-7.8	
	6	-	-		3700	-23.9	
Vehicular	1	0	0	370	0	-2.5	4000
	2	310	-1.0		300	0	
	3	710	-9.0		8900	-12.8	
	4	1090	-10.0		12900	-10.0	
	5	1730	-15.0		17100	-25.2	
	6	2510	-20.0		20000	-16.0	

1) **(10 points)** For channel A, verify that the RMS delay spread figures for the indoor office, pedestrian, and vehicular profiles are equal to 35 ns, 45 ns, and 370 ns, respectively. Estimate the coherence bandwidth for these channels.

2) **(10 points)** Plot the multipath intensity profile function for channel A (pedestrian).

3) **(30 points)** Focusing on the channel A (pedestrian), one can use the Matlab function "rayleighchan()" to simulate a multipath channel. The following code is used to model the required channel.

```
0001 clear all
0002 N = 2000; %number of samples;
0003 OFDMA_Symbol_Time = 102.9e-6;
0004 Tsample = OFDMA_Symbol_Time;
0005 Fdoppler = 45;
0006 PathGainsdB = [0 -9.7 -19.2 -22.8];
0007 RelativeDly = [0 110 190 410]*1e-9; % in nano seconds
0008 c = rayleighchan(Tsample,Fdoppler, RelativeDly, PathGainsdB);
0009 sig = j*ones(N,1); % Signal
0010 y = filter(c,sig); % Pass signal through channel.
0011 c % Display all properties of the channel object.
0012 % Plot power of faded signal, versus sample number.
0013 plot(Tsample*[0:1:N-1],20*log10(abs(y)))
```

In the above code, the signal envelope is sampled every Tsample time. The code selects the OFDMA symbol time of 102.9 micro seconds as the sampling time. Since the code generate N equal to 2000 samples, then the code produces a trace of the channel fading envelope for a duration of $2000*102.9 \times 10^{-6} = 0.218$ seconds. The code plots the power of the signal envelope in dB. Remember the power of the signal envelope is proportional to the square of the absolute value of the signal level.

3.a) Plot the signal power for three different values of the Fdopper parameter: 5 Hz, 50 Hz, and 500 Hz. Put all three resulting curves on one plot and *comment* on the result in terms of speed of variation of the signal level or power. Estimate the coherence time for all three Doppler values.

3.b) The model specifies the MEAN path gains (or equivalently, the mean signal envelope level). The actual individual signal level component for each path is Rayleigh distributed. The code above can store the sample values of the path gain if you set the StorePathGains property of the channel object to 1 before you filter the signal. The stored trace of signal envelope for all multipath components is stored in the PathGains field of the channel object c. For Fdoppler equal to 45 Hz, plot all the multiple components on one figure. You can use "plot(Tsample*[0:1:N-1],20*log10(c.PathGains))" command. Comment on the relative power on the individual components of the multipath.

3.c) Use the channel visualization tool to observe the variation of Channel Impulse Frequency Response (CIFR). Capture several snaps of the showing how the frequency response varies with observation time and some area of the spectrum fade (become small) while others do not.

References:

[1] Overview of Fading Channels:: Channels (Communications Toolbox) – Matlab online help.

Textbook Problems:

Question 3: (30 points) textbook problem 2.2 – assume basestation antenna height of 30 m, mobile antenna height of 2 meters, and $C_M = 0$ dB.

Question 4: (30 points) textbook problem 2.5, and

Question 5: (30 points) textbook problem 2.10.

Hint: For a Rayleigh fading signal envelope, the average rate, $N(\rho)$, the envelope crosses the level A (some arbitrary threshold) is given by $N(\rho) = \sqrt{2\pi}\ B_{D-rms}\ \rho\ e^{-\rho^2}$, where ρ is equal to A/A_{rms}, and $B_{\text{D-rms}}$ is the RMS Doppler spread. A_{rms} is the RMS level of the signal envelope. The average duration of a fade is given by

$$\tau(\rho) = \frac{e^{\rho^2} - 1}{\sqrt{2\pi}\ B_{D-rms}\ \rho}$$