EE 6390 - Introduction to Wireless Communication Systems
Instructor: Dr. Murat Torlak

Team Project A: Physical Layer Simulation of an OFDM System

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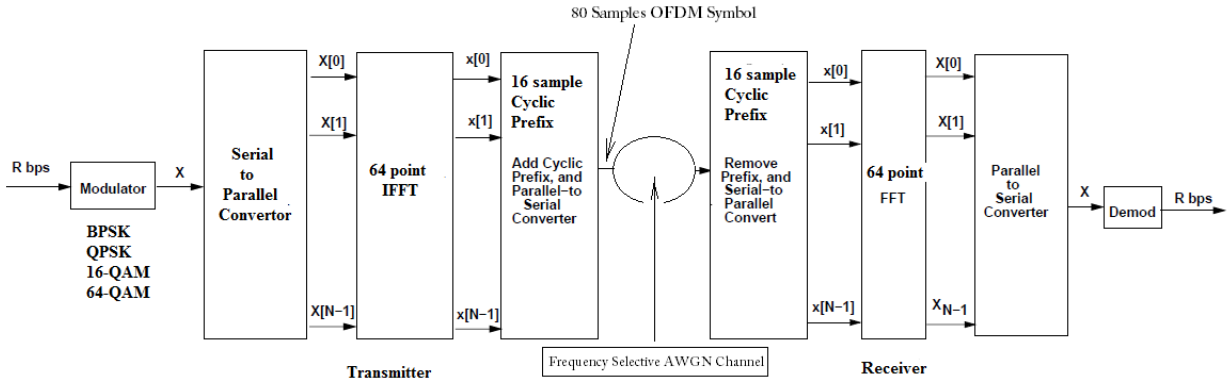
OFDM parameters for IEEE 802.11a standard:

- The IEEE 802.11a Wireless LAN standard occupies 20 MHz of bandwidth in the 5 GHz unlicensed band and is based on OFDM. In 802.11a, *N fft* = 64 subcarriers are generated.
- Out of 64 subcarrier, *Ndata=48* are actually used for data transmission with the outer 12 zeroed *(Nleft=6, Nright=5, Ndc=1*) in order to reduce adjacent channel interference, and *Nref=4* used as pilot symbols for channel estimation.
- The cyclic prefix consists of 16 samples, so the total number of samples associated with each OFDM symbol, including both data samples and the cyclic prefix, is 80.
- Nused=Ndata+Nref=52
- So intervalofpilot = (Nused/Nref)=13 i.e every 13th bit is taken as pilot bit and there will be 4 pilot carriers in total.

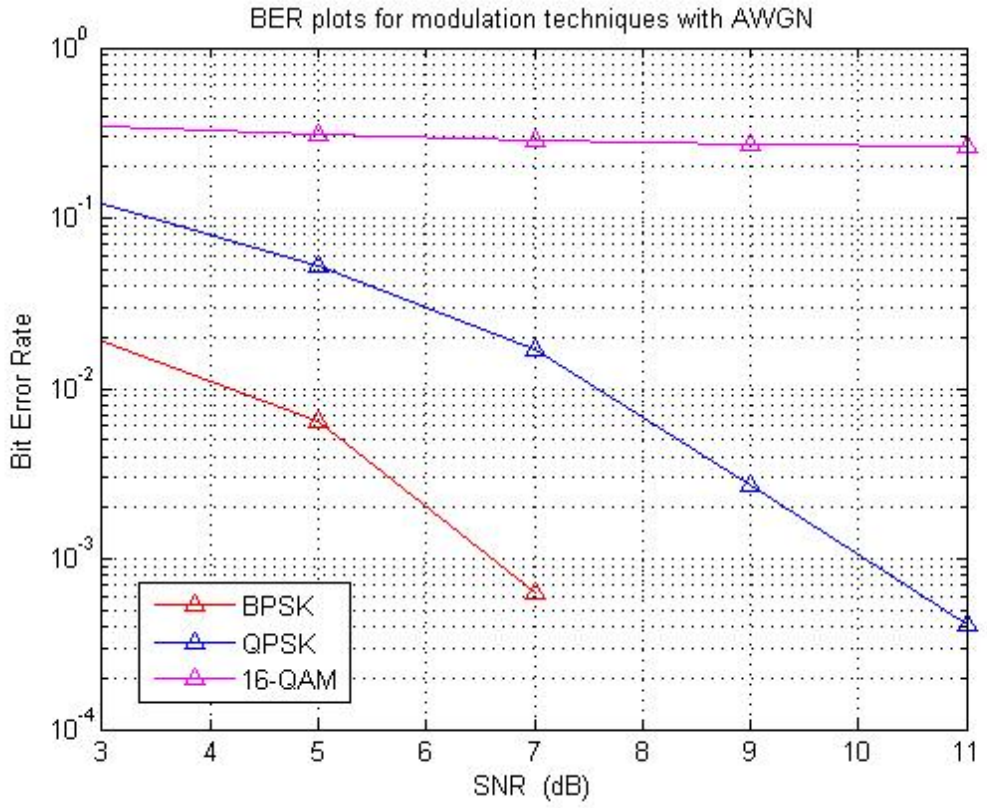
PARAMETERS	VALUES
Channel bandwidth	20 MHz
Modulation types	BPSK,QPSK,16-QAM,64-QAM
FFT size (Nfft)	64
CP length (Ncp)	16
No. of used subcarriers (Nused)	52
No. of pilot subcarriers per symbol (Nref)	4
No. of data subcarriers per symbol (Ndata)	48
No. of null subcarriers (Nleft,Ndc,Nright)	12 Nleft=6, Nright=5, Ndc=1

AWGN Channel Simulation:



OFDM Transmitter-Receiver Block diagram

- For OFDM system with AWGN simulation the SNR is varied from 3 to 11 dB
- BER curve is best for BPSK, then QPSK and the worst case is for 16 QAM .
- This result is expected, since 16-QAM and QPSK packs more bits per symbol into a given constellation than BPSK, so for a fixed energy-per-bit the minimum distance between constellation points will be smaller.

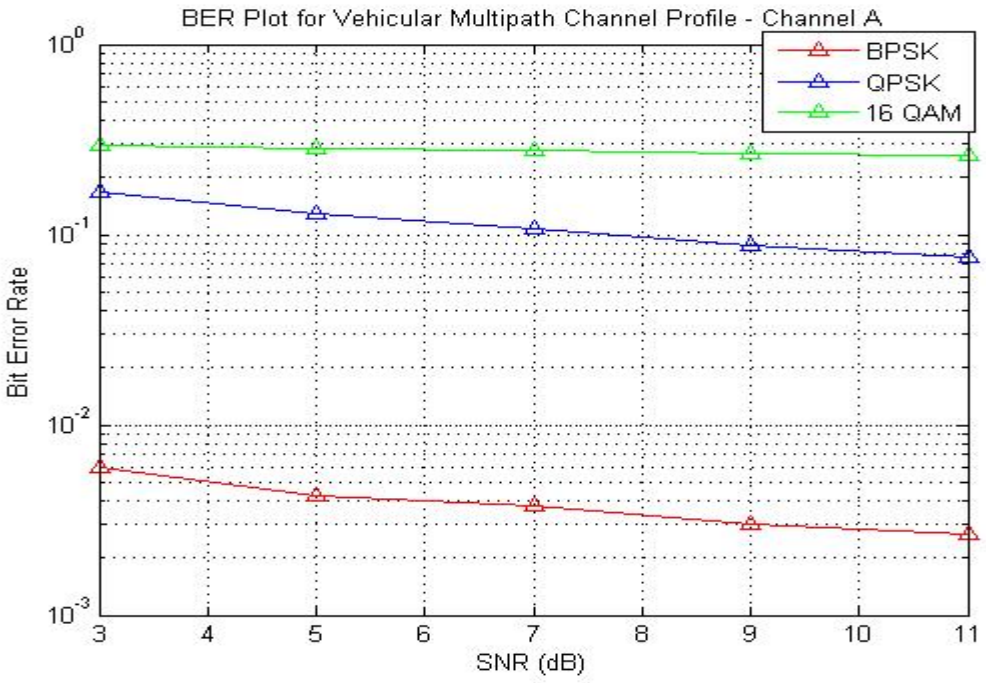


Multipath Channel Simulation

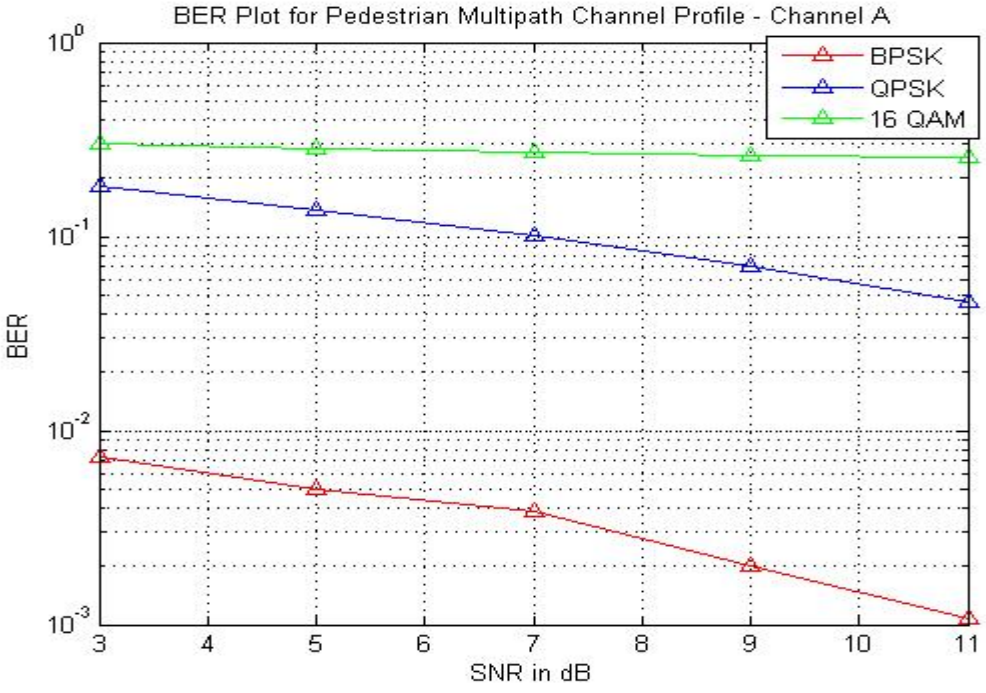
- The transmitted signal is filtered using the given multipath channel models and then corrupted by additive noise.
- The demodulator employs frequency equalization to recover the original symbols.
- The Probablity of bit error due to vs SNR is plotted for the three modulation techniques individually for BPSK,QPSK and 16QAM, under the effect of the channel models.
- The multipath tapped delay line for various environments like Vehicular & Pedestrian models is simulated. The delay parameters are for channel A (as the sum of last digits of UTD ID is even).

The simulation plots for the different models are as follows:

Vehicular Channel Model (Channel A)



Pedestrian Channel Model (Channel A)



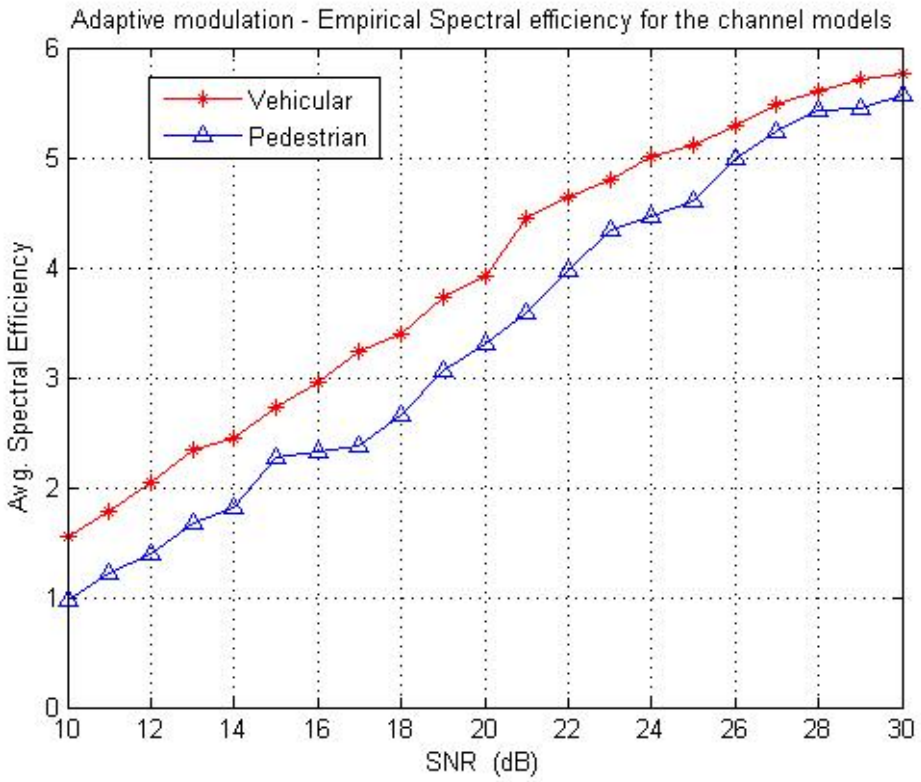
Adaptive Modulation

- The average spectral efficiency of the OFDM transmitter is determined against the received SNR by employing adaptive modulation.
- The SNR is varied from 10 to 30 dB for both the vehicular and pedestrian model.
- For adaptive modulation with a target BER of 10^{-3} and average SNR ranging from 10 to 30 dB, we use the following formula to generate the look up table.

$$P_b = 0.2e^{\frac{-1.5*\gamma}{M-1}}$$

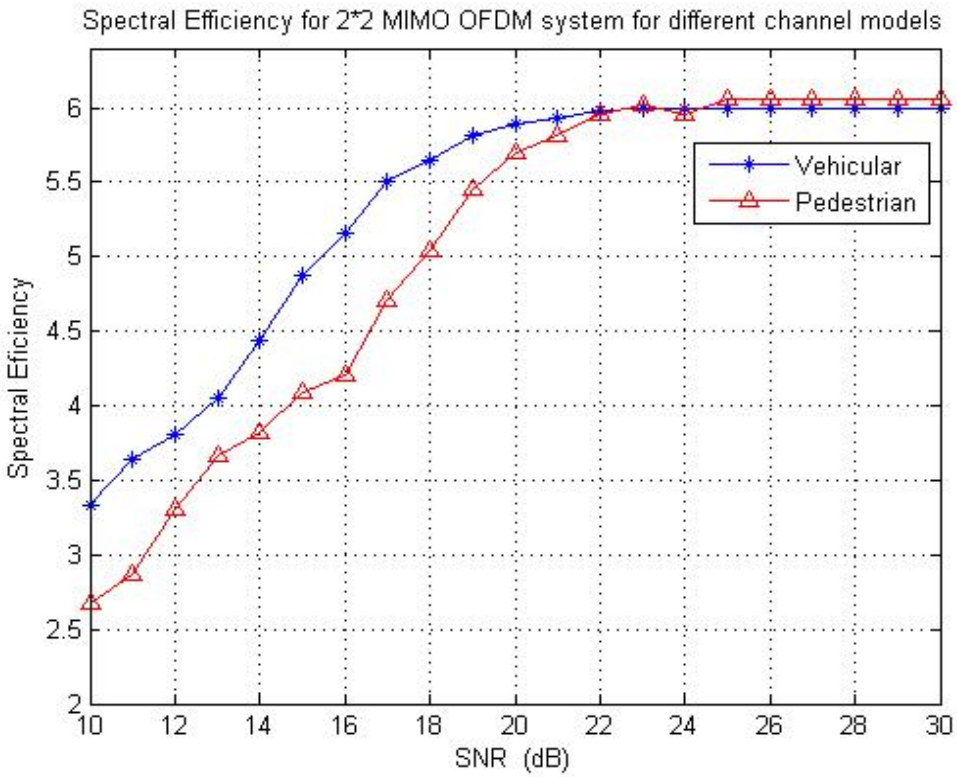
Look-up Table:

SNR Range(dB)	
5.47 to 10.24	BPSK
10.24 to 13.93	QPSK
17.23 to 20.39	16 QAM
Above 23.46	64 QAM



MIMO OFDM Simulation:

For 2*2 MIMO system spectral efficiency is calculated varying SNR from 10 to 30 dB



Compared to Adaptive modulation spectral efficiency is improved using 2*2 MIMO OFDM system as diversity techniques mitigates the effect of multipath fading.

References:

[1]Chapter 12 Multicarrier Modulation, *Andrea Goldsmith*, Wireless Communication

[2] http://www.wirelesstrainingsolutions.com/class/mod/forum/discuss.php?d=14