

## Demo: Simulating 802.11-Like MCS Selection

We first look at MCS selection. Suppose that a channel has fading with three paths with the following parameters. For now, we ignore the delays of the paths since we will assume it is not frequency selective.

```
snrAvg = 15;           % Average SNR in dB
gain = [0, -3, -5]';  % Relative path gains in dB
fd = [0, 10, 7]';     % Doppler shift in Hz

% Random initial phases
npaths = length(gain);
phaseInit = 2*pi*rand(npaths,1);
```

Suppose we transmit a packet every period of 1ms ( $t_{\text{step}}=1e-3$ ) for  $n_t=1000$  steps. We can plot the time evolution of a random realization of the channel as follows.

We can then generate a typical trajectory:

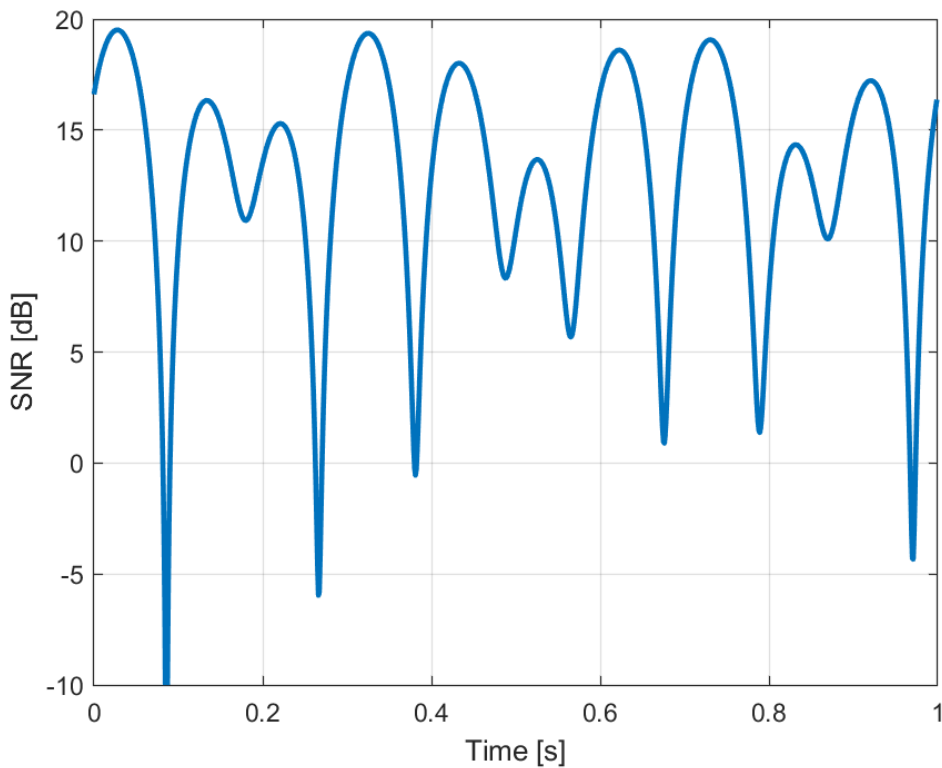
```
% Convert gains to magnitude and normalize to unit average total power
gainLin = db2mag(gain);
gainLin = gainLin / norm(gainLin);

% Compute times
tstep = 1e-3;
nt = 1e3;
t = (0:nt-1)*tstep;

% Compute the narrowband response
h = gainLin'.*exp(1i*2*pi*t*fd' + 1i*phaseInit');

% Compute the fading gain in dB and add it to the average SNR
fade = 10*log10( abs(sum(h,2)).^2 );
snr = snrAvg + fade;

% Plot the SNR over time
clf;
plot(t,snr, 'LineWidth',2);
xlabel('Time [s]');
ylabel('SNR [dB]');
ylim([-10,20]);
grid on;
```



Now suppose the system supports WiFi-like rates as follows:

HT MCS	VHT MCS	Modulation	Coding	20MHz				40MHz			
				Data Rate		Min. SNR	RSSI	Data Rate		Min. SNR	RSSI
				800ns	400ns			800ns	400ns		
1 Spatial Stream											
0	0	BPSK	1/2	6.5	7.2	2	-82	13.5	15	5	-79
1	1	QPSK	1/2	13	14.4	5	-79	27	30	8	-76
2	2	QPSK	3/4	19.5	21.7	9	-77	40.5	45	12	-74
3	3	16-QAM	1/2	26	28.9	11	-74	54	60	14	-71
4	4	16-QAM	3/4	39	43.3	15	-70	81	90	18	-67
5	5	64-QAM	2/3	52	57.8	18	-66	108	120	21	-63
6	6	64-QAM	3/4	58.5	65	20	-65	121.5	135	23	-62
7	7	64-QAM	5/6	65	72.2	25	-64	135	150	28	-61
	8	256-QAM	3/4	78	86.7	29	-59	162	180	32	-56
	9	256-QAM	5/6			31	-57	180	200	34	-54
2 Spatial Streams											

```
nsc = 52;           % number of data subcarriers
tsym = 4e-6;       % OFDM symbol time (using 800ns GI)

% Code rate, modulation rate, minimum SNR and data rate for each of the MCSs
codeRate = [1/2, 1/2, 3/4, 1/2, 3/4, 2/3, 3/4, 5/6]';
modRate = [1,2,2,4,4,6,6,6]';
minSnr = [2,5,9,11,15,18,20,25]';
rate = codeRate.*modRate*nsc/tsym;
```

We can find the optimal MCS for each time  $k$  by finding the highest MCS index  $j$  such that the SNR at that time is greater than the minimum SNR for that MCS. Mathematically, this is given as follows:

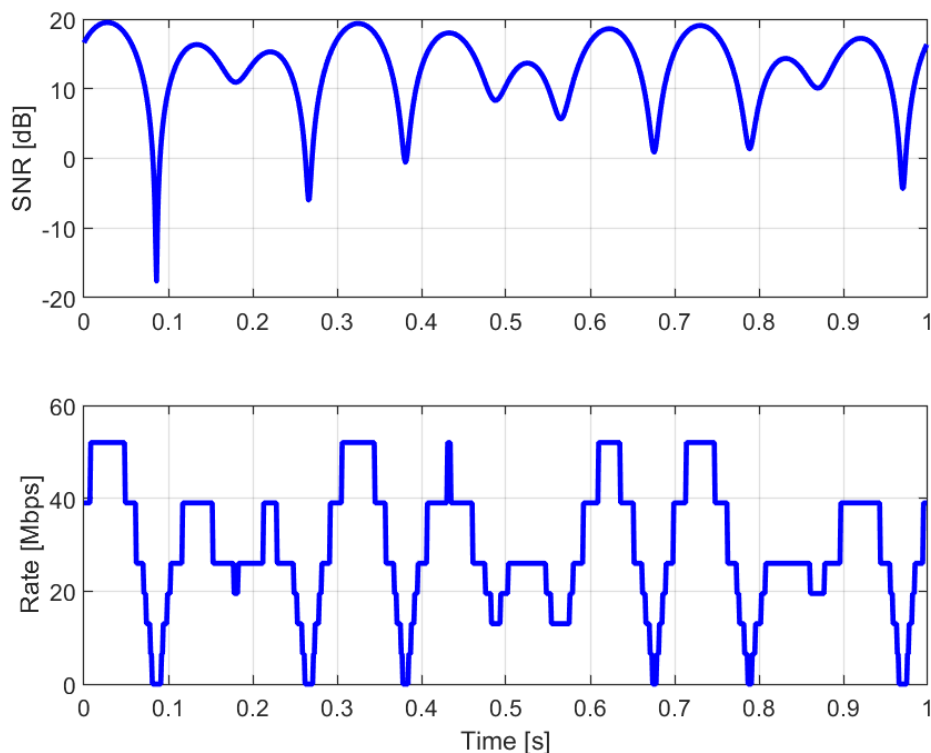
$$\begin{aligned} \text{mcsOpt}(k) &= \max \{ j \mid \text{snr}(k) \geq \text{minSnr}(j) \} \\ \text{rateMax}(k) &= \text{rate}(\text{mcsOpt}(k)) \end{aligned}$$

We can compute this in MATLAB as:

```
[rateMax, mcsOpt] = max((snr > minSnr').*rate', [], 2);
```

We can also plot the rate over time along with the SNR.

```
clf;
subplot(2,1,1);
plot(t,snr,'b-', 'LineWidth',2);
grid on;
ylabel('SNR [dB]');
subplot(2,1,2);
plot(t,rateMax/1e6,'b-', 'LineWidth', 2);
ylabel('Rate [Mbps]');
xlabel('Time [s]');
grid on;
```



## In-Class Problem

We will now try to implement a trial-and-error: Let  $\text{mcsInd}(k)$  be the MCS index attempted in time slot  $k$  and let  $\text{rateAdapt}(k)$  be the goodput in time slot  $k$ . We will adapt this MCS index as follows:

- Start with an initial MCS,  $\text{mcsInd}(1)=1$ .
- At each time  $k$ , check if  $\text{snr}(k) \geq \text{minSnr}(\text{mcsInd}(k))$ , to see if the packet at time  $k$  passes.

- If the packet fails, set  $\text{rateAdapt}(k)=0$  since no data was transmitted. Also, decrement the MCS index for the next slot.
- If the packet passes, set  $\text{rateAdapt}(k)$  based on the rate achieved in that time slot. Also, with probability  $p_{up}$  try increase the MCS index for the next slot.

Plot the  $\text{rateAdapt}$  vs. time.

```
% TODO
```

The previous data rate is difficult to visualize. Filter the rate,  $\text{rateAdapt}$ , with a moving average of  $\text{filLen}=10$  time steps. Plot the smoothed rate and the maximum rate vs. time.

```
clf;  
filLen = 10;  
  
% TODO
```