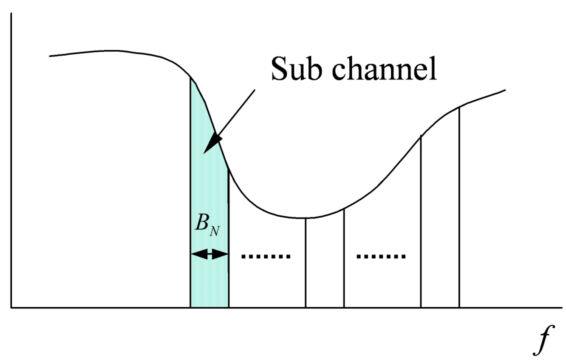
Wireless Communications
Lecture 13

Multicarrier Modulation(Chapter 12)

[Multi-Carrier Systems]

A way to combat ISI



[Example] Total given Bandwidth of 1MHz, delay spread of 20 μs. How many subchannels?

$BW_{\text{coh}} = \frac{1}{20\mu s} = 50$ KHz $\Rightarrow B_N << BW_{\text{coh}} \Rightarrow B_N = 5$ KHz.
Therefore, $N = 200$ or 256 in discrete implementation.

[Adaptive Loading]

Assume a total power constraint $\bar{P}$, then capacity is given by

$$C = \max_{P_i : \sum P_i = \bar{P}} \sum_{i=0}^{N-1} B_N \log_2 \left(1 + \frac{\alpha_i^2 P_i}{N_0 B_N}\right)$$

water filling over frequency given by Eq (4.24) in A.G. book

$$\frac{P_i}{\bar{P}} = \begin{cases} 1/\gamma_c - 1/\gamma_i & \gamma_i \geq \gamma_c \\ 0 & \gamma_i < \gamma_c \end{cases}$$

The capacity is

$$C = \sum_{i:\gamma_i \geq \gamma_c} B_N \log_2\left(\frac{\gamma_i}{\gamma_c}\right)$$

Now adapting power & rate for MQAM.

The data rate is

$$R = \sum_{i=0}^{N-1} B_N \log_2\left(1 + \frac{K\gamma_i P_i}{\bar{P}}\right), \quad \sum_{i=0}^{N-1} P_i = \bar{P}$$

Optimizing the data rate equation relative to the P_i yields the optimal power allocation with $K = \frac{-1.5}{\ln(5P_b)}$

$$\frac{KP_i}{\bar{P}} = \begin{cases} \frac{1}{\gamma_K} - \frac{1}{\gamma_i} & \gamma_i \geq \gamma_K \\ 0 & \gamma_i < \gamma_K \end{cases}$$

data rate is

$$R = \sum_{i:\gamma_i \geq \gamma_K} B_N \log_2\left(\frac{\gamma_i}{\gamma_K}\right)$$

where γ_K is a cutoff fade depth dictated by the power constraint $\bar{P}$ and K.

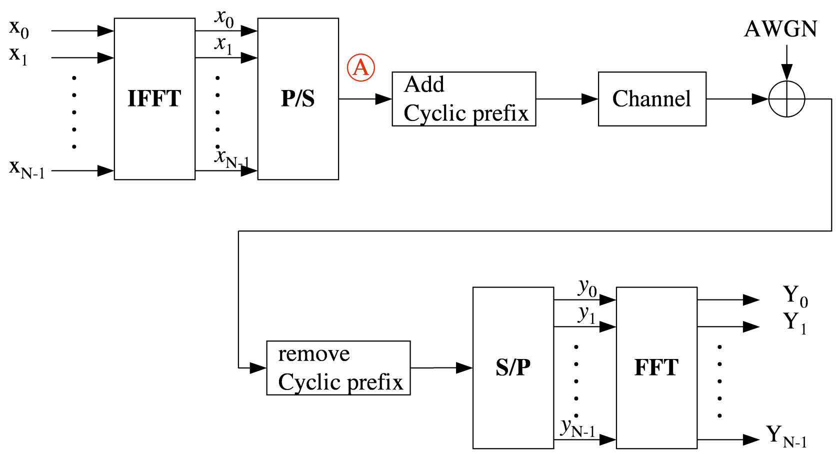
[Discrete Implementation of Multi-carrier Modulation]

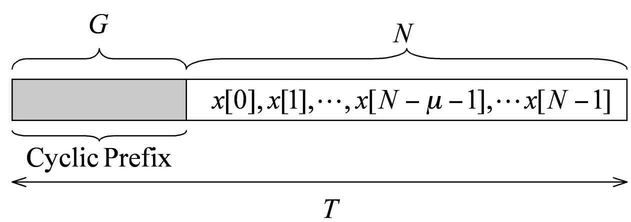
For multiplication in frequency domain need cyclic convolution in time domain.

- Need to add cyclic prefix to prevent Inter-OFDM symbol Interference.
- CP length is maximum predicted delay spread.

Let the channel taps be $h_0, h_1, \ldots, h_M$.

$h_0\mathbf{x}$	x_0	x_1	$\ldots$	x_{N-1}		
$h_1\mathbf{x}$	x_{N-1}	x_0	x_1	$\ldots$	x_{N-1}	
$h_2\mathbf{x}$	x_{N-2}	x_{N-1}	x_0	x_1	$\ldots$	x_{N-1}





Circular convolution

$$y_n = \sum_{i=0}^{M} h_i x((n-i))_N$$

CP is the last M samples of the data