Experiment No. 10

AIM: **To analyze the effect of multipath diversity on Bit Error Rate in CDMA system.**

Theory: In mobile communication, Multipath propagation results in an antenna receiving two or more copies of the signal sent from the same source but that has been delivered via different paths. Multipath components are treated as redundant copies of the original signal and are used to improve the performance of the system by minimizing bit error rate. It also improves the data transmission reliability and increase the bit rate over the wireless communication channel. In CDMA, RAKE receiver is used to extract the multipath diversity. A rake receiver utilizes multiple correlators to separately detect the *M* strongest multipath components.
Consider frequency selective channel i.e. channel BW is less than signal BW.

Consider symbol transmission $x(0), x(1), x(2), - - - x(n)$
Wireless channel model is

$$y(n) = hx(n) + w(n)$$

Where $y(n)$ is received signal
h is fading channel coefficient
w is Independent Identically Distributed (IID) Gaussian Noise with mean zero and variance σ^2.

With multipath components the received signals

$$y(n) = \sum_{l=0}^{L-1} h(l)\, x(n-l) + w(l)$$

Where $h(l)$, multipath channels
$x(n-l)$, signal received via multipath component.

Consider CDMA system and assume user is transmitting symbol = a_0
Code for user is $C_0(n)$.

In CDMA symbol is multiply with code = $a_0 \times C_0(n)$

$$y(n) = \sum_{l=0}^{L-1} h(l)\, a_0 C_0(n-l) + w(l)$$

At the receiver to extract the user symbol, correlate $y(n)$ with $C_0(n)$.

$$\check{y}(n) = \frac{1}{N}\sum_{n=0}^{N-1} y(n) C_0(n)$$

$$\check{y}(n) = \frac{1}{N}\sum_{n=0}^{N-1}\sum_{l=0}^{-1L} h(l)\, a_0 C_0(n-l) C_0(n) + \frac{1}{N}\sum_{n=0}^{N-1} w(l)\, C_0(n)$$

In the above equation first term is line of sight component and all the multipath components. Second term is Gaussian noise components with mean zero and variance σ^2/N.
From the above equation with Maximal Ratio Combining

$$SNR_{Received} = \frac{\| \bar{h} \|^2 P}{\sigma^2/N}$$

$$SNR_{Received} = \| \bar{h} \|^2 N \times \frac{P}{\sigma^2}$$

$$SNR_{Transmitted} = \frac{P}{\sigma^2}$$

$$SNR_{Received} = \| \bar{h} \|^2 N \times SNR_{Transmitted}$$

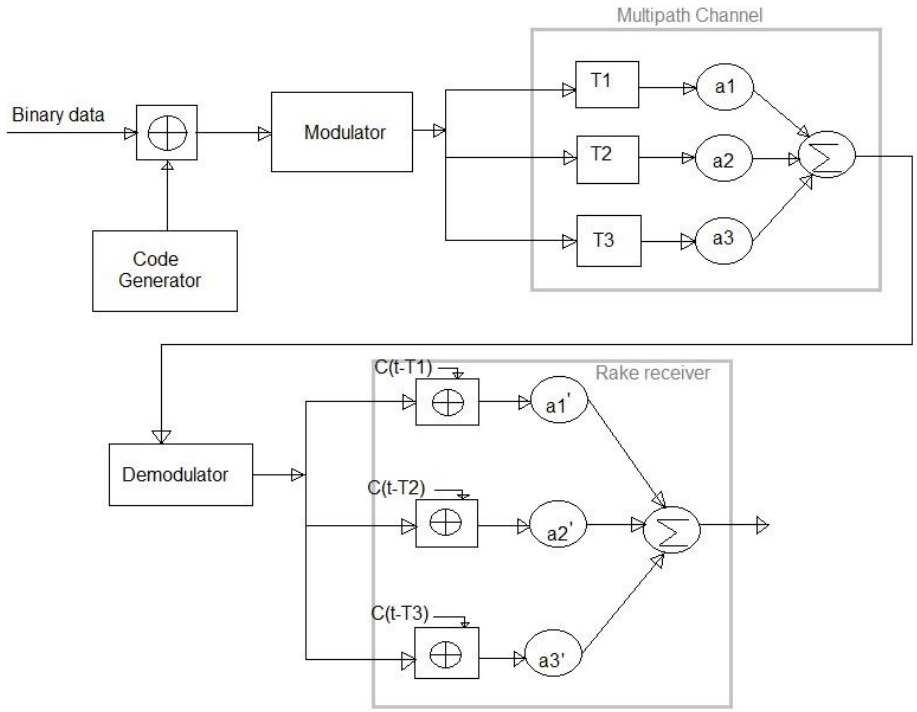
$$\| \bar{h} \|^2 = (|h(0)|^2 + |h(1)|^2 + |h(1)|^2 - - + |h(L-1)|^2)$$

Bit Error rate of CDMA system at high SNR

$$BER = C_L^{2L-1} \left(\frac{1}{2N \times SNR} \right)^L$$

Where, L is number of Taps or finger
N is spreading factor.

RAKE Receiver Diagram:



Problem: For the given parameters calculate BER and analyze the results
N= 256, 64 and L=3 taps, 4 taps

Answer the following question

1) What is diversity and explain types of diversity.
2) How RAKE receiver improves the gain.

Conclusion: