ASSIGNMENT # 5

Raleigh Fading channel:-

TYPES OF FADING:-

① Large Scale Fading:-
② Small Scale Fading:-

Large Scale Fading:-

Large Scale fading represents the averag signal power attenuation or path loss due to motion over large areas. This is due to prominent terrains

There are three mechanisms that impacts signal propagation.

→ Reflection through smooth surfaces with very large dimension compared to RF signal wavelength.

→ Diffraction occurs when the radio path between the transmitter and reciever is obstructed by a dence body. It accounts for RF energy ~~travelled~~ travelling from tx to rx without line of sight. (knife edge diffraction).

→ Scattering occurs when radio waves strikes large rough surface or any surface having dimension of order λ or less, causing the reflected energy to scatter (spread out), in all directions.

While estimating path loss we should consider:

→ Mean path loss as a function of distance due to large scale fading.

→ Near-worst-case variation about the mean path loss or large scale fading margin.

→ Near worst case Raleigh or small-scale fading margins.

Recieved Signal is a convolution result of signal and impulse Response of channel.

$$r(t) = s(t) * h(t)$$

In case of mobile radios

$$r(t) = m(t) \times r_0(t)$$

→ log-normal fading

$m(t)$ = large scale fading Component (local mean)

$r_0(t)$ = small scale fading Componet.

→ multipath or Raleigh fading.

Large Scale Fading channel:

$$L_s(d) = \left(\frac{4\pi d}{\lambda}\right)^2$$

Large scale fading is characterized by average path loss and shadowing. Large scale fading ~~...~~ tells us about the power loss of signals in the case of large distance transmitter and reciever.

Mean path loss $\quad \overline{L_p(d)} \propto \left(\frac{d}{d_0}\right)^n$

$$\overline{L_p(d)}(dB) = L_s(d_0)(dB) + 10\,n \log(d/d_0)$$

d_0 = reference distance to a point located in the far field of antenna, typically 1 km

$\overline{L_p(d)}$ = average path loss for a given value of d.

Value of n depends upon frequency antenna height and propogation environment.

The path loss $L_p(d)$ is a random variable having a log normal distribution about the mean distant-dependent value $\overline{L_p(d)}$.

so

$$L_p(d)(dB) = L_s(d_0)(dB) + 10n\log_{10}(d/d_0) + X_\sigma\,(dB)$$

X_σ = zero mean gaussian random variable.

σ = standard deviation of X.

⇒ So parameters needed to describe path loss in large scale fading channel are:

→ The reference distance d_0.

→ σ standard deviation of X_σ.

→ n, the path loss exponent

Small Scale Fading Channel :

Small scale fading is used to describe the rapid fluctuation of the amplitude, phases, or multipath delays of radio signals over a short period of time or travel distance. Also known as Raleigh Fading

Small scale Fading manifests in 2 ways.

→ Time Spreading of the underlying digital pulses within Signal

→ A time variant behavior of the channel due to motion.

MP

Small-scale Fading (Based on time delay spread)

Flat Fading

1. BW of Signal < BW of channel
2. Delay Spread < Symbol period

Frequency Selective Fading

1. BW of Signal > BW of channel
2. Delay Spread > Symbol period

3.

(Based on Doplar Spread)

Small Scale fading

Fast Fading
1- High dopplar Spread
2. ~~Cho~~ Coherence time < Symbol period
3. Channel variations faster than baseband Signal variation

Slow fading.
1. Low Dopplar Spread.
2. Coherence time > Symbol period
3. Channel variation Slower than base band Signal variation

Time Spreading:-

It tells how the average power of recieved Signal varies as a function of time delay. ~~It represents~~ The Time delay is used to refer excess delay. It represents signal propagation delay that exceeds the delay of the first signal arrival at the reciever.

Frequency Selective fading:-

When maximum delay of the recieved Signal exceeds Symbol time. Also known as ~~ISI~~ channel induced ISI. Mitigation of this is possible because many multipath components of recieved Signal are resolved at reciever.

Frequency Non-selective or Flat fading:-

All the recieved multipath components of symbol arrive with in the symbol duration. So there is no channel-induced ISI so no overlapping among symobols occur. Due to unresolved phasor component SNR reduces.

The Variance of channel:-

Duality:-

When the behaviour of one with reference to a time-related domain (time or time delay) is identical to the behaviour of the other in reference to the corresponding frequency related domain (frequency or Dopplar shift).

FAST FADING:-

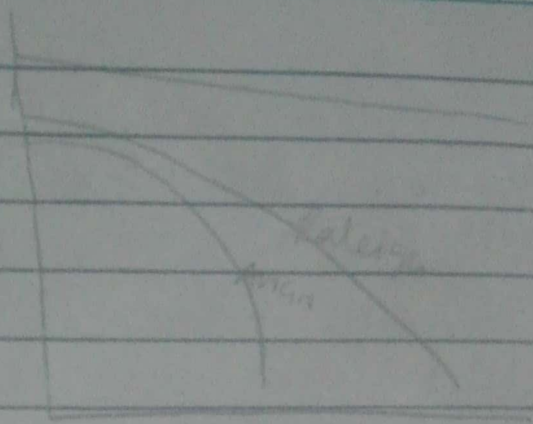
It is used to describe channel in which $T_0 < T_s$ where T_0 is chanel coherence time and T_s in time duration of a transmission ~~signal~~ Symbol. So channel changes its properties sereal time during signal propogation resulting in loss of SNR.

SLOW FADING:-

$T_0 > T_s$, when channel coherence time is greater then symbol time. So channel properties remain same during signal propogation.

MITIGATION METHODS:-

AWGN → the good
Raleigh → Bad
Frequency selective / Fast fading
↳ awful.



In AWGN with resonable amount of Eb/No the performance is good. The middle curve represent bad which is Raleigh limit, which results in Loss of SNR. So for reasonable values of SNR performance is bad. The top most reaches an irreduceable level some times called error flow, represents awful performance. This shows the severe distorting effects of frequency selective fading or fast fading

We use some form of mitigation for frequency selective or fast fading to remove distortation and ~~[illegible]~~ Error reduces to Rayleigh limit and we try to achieve AWGN performance.

MITIGATION FOR FREQUENCY SELECTIVE DISTORTION:-

EQUALIZATION-

The process of equalizing the ISI involves some method of gathering the dispersed symbols energy back together into its original time interval. We design a filter which combines with channel to yield that response with linear phase.

As channel respone varies with time, our filter should be adaptive.

→ DECISION FEEDBACK EQUALIZER:- (DFE)

~~The ba~~ It works in a way that once an information symbol is deteced, the ISI it induces on future symbols can be estimated ~~a~~ and subtracted before the detection of subsequent symbols.

→ ~~MAXIMUM~~ MAXIMUM LIKELIHOOD SEQUECE ESTIMATION:-

MLSE equalizer tests all the possible data sequence (rather than decoding each recieved symbol) and chooses the most probable data sequence. It is optimal because it minimizes the probability of sequence error. Also Refered as viterbi equalizer.

Other techniques to mitigate frequency selective ISI are:-

→ Spread Spectrum techniques.

→ Frequency-hopping Spread Spectrum (FH/SS)

→ Orthogonal frequency-division Multiplexing (OFDM)

MITIGATION TO COMBAT LOSS IN SNR:-

→ Time diversity:- Transmit signal on L different time intervals with time separation of T_c.

→ Frequency diversity. Transmit signal at L different carrier frequencies with frequency separation of f_0.

RAKE RECIEVER:-

Rake Reciever counters ~~effects~~ effects of Multipath fading. It uses sub recievers, that is several correlators each assigned to different multipath components. Each correlator decodes a single multipath component. Later contribution of all correlators is combined to make the most use of different transmission characteristics of each transmission path.