22/01/24 E4

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→ Ortha signals helps in concurrent signal propagation

for free space path loss, the path loss is $\boxed{\frac{P_t}{P_r} = \frac{(4\pi d)^2}{\lambda^2}}$

I sum on this

$\Rightarrow \boxed{\frac{P_t}{P_r} = \left(\frac{4\pi}{\lambda}\right)^2 d^n}$ → n is some higher value due to external factors.

⇒ predicted path loss for urban environment according to commonly used Okumura-Hatta model

$$\boxed{L_{dB} = 69.55 + 26.16\log f_c - 13.82\log h_t - A(h_r) + (44.9 - 6.55\log h_t)\log d}$$

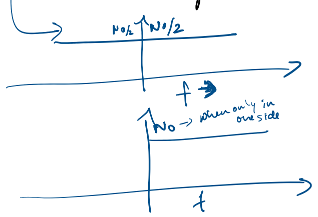
↳ imperical model; f_c → MHz; h_t → m; $A(h_r)$ → correction factor; d → kms (propagation distance)

⇒ $\boxed{\text{Noise power } N = kTB}$ where k = Boltzman constant in J/K $= 1.38\times10^{-23}$ J/K

T = Temperature in kelvin, B = Bandwidth in Hz

Noise (independant of frequency)

- → Thermal noise → for noise to be 0, we need 0 K / −273°C which is not practical possible
  - → uniformly distributed across frequency spectrum & hence referred as white noise
- → intermodulation noise: happens due to non-linearity in the system
  - ↳ when 2 signals are mixed, there will be higher order systems due to non-linearity of the system
- → cross talk
- → impulse noise: fluctuations in electric systems



} graphical representation of noise ↳ in order of 10^{-9} watts.

0 dBW ⇒ 1 watt

dBm → dBW : subtract by 30 dB ($1000 = 30$ dB)

dBW → dBm : add 30 dB

dBm	dBW
0	−30
30	0
60	30
90	60

conversion ←

⇒ $N = 10\log k + 10\log T + 10\log B$

$= -228.6\text{ dBW} + 10\log T + 10\log B$

⇒ E_b = energy per bit

$$\boxed{\frac{E_b}{N_0} = \frac{S/R}{N_0} = \frac{S}{kTR}}$$

S/R → SNR; R = data Rate

$$\frac{E_b}{N_0} = \frac{S}{N_0 R} \; ; \; \frac{E_b}{N_0} = \frac{SB}{NR} \qquad B = \text{Bandwidth}$$

min SNR → sender (airtel)

max SNR → receiver (user)

$\boxed{\log_2 a = \frac{\log a}{\log 2}}$

⇒ $\frac{C}{B}$ = spectral efficiency in bits/Hz

Shannon's Eq: $C = B\log_2(1 + S/N)$

⇒ $\frac{S}{N} = 2^{C/B} - 1$, C = capacity of channel

$$\therefore \boxed{\frac{E_b}{N_0} = \frac{B}{C}\left(2^{C/B} - 1\right)}$$ successfully replaced SNR with B/C

HW: $\lim_{B\to\infty} C = B\log_2\left[1 + \frac{S}{N}\right]$, $N = N_0 B$

Multipath Propagation (MPP)

1. MPP is due to reflection
2. MPP is due to diffraction
3. MPP is due to scattering
4. MPP is due to doppler effect

MPP will manifest into attenuation & ISI

↳ effects of MPP

⇒ Example for refraction: Troposcatter

Refraction.

③ MPP is due to scattering
④ MPP is due to doppler effect

→ Example for refraction: ... Refraction.

Fading in Mobile Environment

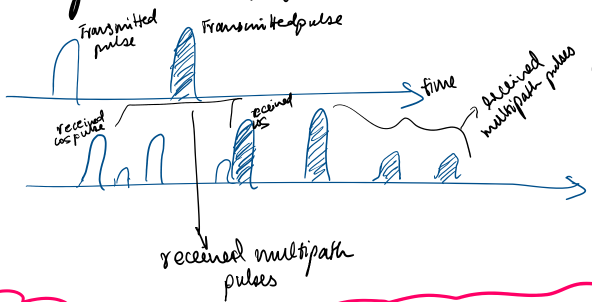
→ reduction in the level of signal in an unreliable manner

- Fading is due to change in path
- moving antennas creates complex transmission paths
- Large scale fading → low degradation of signal
  small " " → rapid degradation of signal

Reflection: occurs when the reflector size is larger than wavelength

Diffraction: occurs at the edge of an impenetratable body that is large compared to wavelength of radio wave.

Scattering: If the size of the obstacle is in the order of the wavelength of the signal



1sec → 300,000 km
1μsec → 300m

MPP in frequency is coherence (something).

Flat Fading and Frequency selective fading

vvv imp

↳ results in ISI

↳ will come in ESA/ESA pakka

Fading Channel

① for thermal noise, AWGN is a suitable model
② Rayleigh fading, occurs when there are many paths
Eg: Manhattan Bridge
③ Rician fading

Solution for frequency selective fading:

→ flattening the channel (is NOT a solution cause channel is not in our control)
→ reducing the no. of data that you send → we are more interested in BW hungry application
↳ i.e. increase symbol width

① Equalization → $T_x \rightarrow \boxed{|H|} \rightarrow R_x$
↳ $T_x \rightarrow \boxed{\frac{1}{|H|}} \rightarrow \boxed{|H|} \rightarrow R_x$
↳ reverse the ill effect.

② Adaptive modulation

QAM → 4bits/symbol
QPSK → 2bits/symbol
BPSK → more robust

③ Forward error correction (FEC) | Backward error correction: to send again
↳ send dummy bits & using these dummy we correct the error
↳ The receiver corrects the errors in received bits with the help of redundant bits in received bits
Eg: Huffman codes, Hamming codes, BCH code

④ OFDM → uses multiple orthogonal subcarriers

HW: ① coherence BW ② coherence time ③ slow fading ④ fast fading ⑤ flat fading ⑥ frequency selective fading

HW : (1) coherence BW (2) coherence time (3) slow fading (4) fast fading (5) flat fading (6) frequency selective fading

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