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1) 50 kHz Duplex ch. 7 cell reuse (N) C = 19200 channels

a) $SIR = \frac{q^n}{i_0}$; n → pathos exponent ; i_0 → # of co-channels in first layer ; $n=4$, $i_0=6$, $N=7$

① $SIR = \frac{q^4}{6}$; where $q = \sqrt{3N}$, $q = \sqrt{21}$

$= \frac{(\sqrt{21})^4}{6}$

$SIR = 73.5$

② $SIR[dB] = 10\log_{10} 73.5 = 18.66 dB$ (OR 48.66 dBm)

b) If we want to reduce the interference, we should increase N. (which is cluster size) Also, known # of cells.

$SIR = \frac{q^n}{i_0}$ $q = \sqrt{3N}$ $C = M.S = M.k.N$

$S = k.N$

$S = \frac{20.000 kHz}{50 kHz} = 400$ channels

$k = \frac{S}{N} = \frac{400}{7} = 57.14 \cong 57$ channels/cell

$M = \frac{C}{S} = \frac{19200 ch.}{400 ch.} = 48$ clusters

I suggest new cluster size which is $\overset{(2)}{i^2} + \overset{(2)(2)}{ij} + \overset{(2)}{j^2} = 12$ (N=12)

$M'.N' = M.N$

$M' = \frac{48.7}{12} = 28$

$\boxed{C' = M'.S' = 28 . 400 = 11200}$

$q' = \sqrt{3.N'} = 6$

$SIR' = \frac{6^4}{6} = 216$ $\boxed{SIR'[dB] = 10\log_{10} 13.5 = 23.34 dB}$

M	M'
48	128

N	N'
7	12

C	C'
19,200	11,200

SIR	SIR'
18.66	23.34

c) The capacity is decreased as you can see above. When we increase the cluster size, the area does not change. Thus, # of clusters are decreased to cover the same area, this makes the capacity lower.

2) $C = 35$ channels $\quad GOS = 0.05$

In a blocked-calls cleared, we should look at erlang B table.

$$A = 30$$

$$A = U.A_U = U.\lambda.H$$

$U = 500$ # of Users

$$A_U = A/U = 30/500 = 0.06$$

$$A_U = \lambda.H = \lambda \times 1.2 \text{ minutes}$$

$$\lambda = \frac{0.06}{1.2} = 0.05 \text{ calls/min}$$

We need to find average # of calls that each user makes per hour;

$$\boxed{\lambda = 0.05 \frac{\text{calls}}{\cancel{\text{min}}} \times \frac{60 \cancel{\text{min}}}{1 \text{ hour}} = 3 \text{ calls/hour}}$$

3) $D = 1m$, $f = 900$ MHz , $P_t = 50$ watt , $h_{te} = 40$, $h_{re} = 5$, $d = 1$ km

$1000 > h_{te} > 30$

$10 > h_{re} > 3$

$G_{hre} = 20 \log (h_{re}/3)$

For far-field distance ; $d_f = \dfrac{2D^2}{\lambda}$; $d_f \gg D$, $d_f \gg \lambda$

$$\lambda = \frac{3.10^8 m}{900.10^6} \cong 0.33\,m$$ (In the 4rd question we found the same value.)

$$d_f = \frac{2.(1)^2}{0.33} \cong 6.06m$$

If $d_f \gg D$ and $d_f \gg \lambda$ are true, we cand find the Okumuro model.

$\underbrace{6.06 \gg 1}_{\text{enough}}$, $\underbrace{6.06 \gg 0.33}_{\text{true}}$

$$P_r(d) = \frac{P_t . G_T . G_r . \lambda^2}{(4\pi)^2 . d^2 . L}$$

we don't need that much $\rightarrow$ true

$$P_r(1km) = \frac{50 . 1 . 1 . (0.33)^2}{(4\pi)^2 . (1000)^2 . 1} = 3.448 \times 10^{-8}$$

$$P_r(1km)\,[dB] = 10 \log_{10}(3.448 \times 10^{-8}) = -74.57\,dB$$

$$P_r(1km)\,[dBm] = -74.57 + 30 = -44.57\,dBm$$

$$P_t\,[dB] = 10 \log_{10} 50 \cong 16.99\,dB$$

$$P_t\,[dBm] \cong 46.99\,dBm$$

$$L_F = P_t - P_r(1km) = 16.99 - (-74.57) = 91.56\,dB$$

$A_{mu}(f,d) = A_{mu}(900, 1km) \cong 19\,dB$ (from the chart)

$$G(h_{te}) = 20 \log (h_{te}/200) = 20 \log (40/200) \cong -13.98\,dB$$

$$G(h_{re}) = 20 \log (h_{re}/3) = 20 \log (5/3) \cong 4.44\,dB$$

$G_{AREA} \cong 9.5\,dB$ (In Suburban Area, it is really close to 10 in chart)

$$L_{50}\,[dB] = L_F + A_{mu}(900, 1km) - G(h_{te}) - G(h_{re}) - G_{AREA}$$

$$= 91.56 + 19 - (-13.98) - 4.44 - 9.5$$

$$L_{50}\,[dB] = 110.6\,dB$$

Link Budget : $P_r\,[dBm] = 44.57\,dBm + 0 - 110.6\,dB = -66.03\,dBm$

4)
a) $\bar{\tau} = \dfrac{(0.1).0 + 1.(2)}{(0.1)+1} = \dfrac{2}{1.1} \cong 1.82$

$\bar{\tau^2} = \dfrac{(0.1).0^2 + 1.2^2}{0.1+1} = \dfrac{4}{1.1} \cong 3.64$

$\rightarrow \sigma_\tau = \sqrt{\bar{\tau^2} - (\bar{\tau})^2} = \sqrt{3.64 - (1.82)^2} \cong 0.57\ \mu s$

$B_c = \dfrac{1}{5\sigma_\tau}$ (Threshold is 0.5 correlation)

$B_c = \dfrac{1}{5\times(0.57)} = \dfrac{1}{2.85} \cong 0.351\ \mu s \cong 351\ kHz$

$B_s << B_c$ and $B_s > B_c$

$200 << 351$ $\quad$ $200 \cancel{>} 351$

We have flat fading.

Thus, this channel don't need an equalizer.

b) $f_c = 900\ MHz \longrightarrow \lambda = \dfrac{3.10^8}{900.10^6} = 1/3 = 0.33m$

$f_m = \dfrac{120.10^3 \cancel{m} / 3600 s}{0.33 \cancel{m}} \cong 101.01\ Hz$

$T_c = \sqrt{\dfrac{9}{16\pi f_m^2}} = \sqrt{\dfrac{9}{16.\pi.(101.01)^2}} = \sqrt{1.755 \times 10^{-5}} = 4.2\times10^{-3} = 4.2\ ms$

$\boxed{T_c = 4.2ms}$

$R_b = 200\ kbps$

For BPSK $R_b = R_s \rightarrow R_s = 200 kbps$

$T_s = 1/R_s = 1/\underbrace{200.10^3}_{10^5} = 5\mu s$ $\quad \boxed{T_s = 5\mu s}$

$T_c >> T_s \longrightarrow 4.2\,ms >> 5\,\mu s$

$4.2\times10^{-3}s >> 5.10^{-6}s$

In this reason; the channel is slow fading.