3.1 $B = 33\,MHz$

2 half-duplex channels at 25 KHz $\rightarrow L_{ch} = 50\,KHz$

N° possible channels $= \frac{B}{L_{ch}} = 660$

a) Channels per cell $= \frac{660}{4} = 165$

b) Channels per cell $= \frac{660}{7} \approx 94$

c) Channels per cell $= \frac{660}{12} = 55$

With 1 MHz dedicated to the control channels

$B' = B - 1\,MHz = 32\,MHz$

N° possible voice channels $= \frac{B'}{L_{ch}} = 640$ voice channels

N° possible control channels $= \frac{1\,MHz}{L_{ch}} = 20$ control channels

a) Voice ch $\rightarrow \frac{640}{4} = 160$ | Control ch $\rightarrow \frac{20}{4} = 5$

b) Voice ch $\rightarrow \frac{640}{7} = 91$ ou 92 | Control ch $\rightarrow \frac{20}{7} = 3$ ou 2

b) Voice ch $\rightarrow \frac{640}{12} = 53$ ou 54 | Control ch $\rightarrow \frac{20}{12} = 2$ ou 1

3.2 $N = i^2 + ij + j^2$ (Cell range)

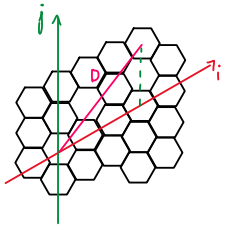
$Q = \frac{D}{R}$ (Co-channel reuse Ratio)

D (Reuse distance)

R (Cell radius)

d (distance between cells)

$d = 2R\cos(30) = \sqrt{3}R$



Cosine Rule

$a^2 = b^2 + c^2 - 2cb\cos(A)$

$a^2 = D^2$

$b^2 = (id)^2$

$c^2 = (jd)^2$

$A = 120^{\circ}$

So:

$D^2 = (id)^2 + (jd)^2 - 2\,id\,jd\cos(120^{\circ}) \Leftrightarrow$

$\Leftrightarrow D^2 = d^2\left(i^2 + j^2 - 2ij\left(-\frac{1}{2}\right)\right) \Leftrightarrow$

$\Leftrightarrow D^2 = d^2(i^2 + ij + j^2) \Leftrightarrow$

$\Leftrightarrow D^2 = d^2 N \Leftrightarrow D^2 = 3R^2N \Leftrightarrow \frac{D}{R} = Q = \sqrt{3N}$ //

3.3 $Q = \frac{D}{R} = \sqrt{3N}$ ($n = 3$ path loss exponent)

$\frac{C}{I} = 15\,dB$ $\qquad \frac{C}{I} = \frac{P_{rec}}{\sum_{i=1}^{6} P_{int}} = \frac{R^{-n}}{\sum_{i=1}^{6} d^{-n}} = \frac{1}{6}\left(\frac{D}{R}\right)^n$

$d_1^{-n} + d_2^{-n} + d_3^{-n} + d_4^{-n} + d_5^{-n} + d_6^{-n} \sim 6D^{-n}$

a) $n = 4$ $\quad \frac{C}{I} = 15\,dB = 10\log_{10}\left(\frac{1}{6}\sqrt{3N}^n\right)$

$N = \frac{\sqrt[2]{6 \cdot 10^{1.5}}}{3} = 4.59 \Rightarrow N = 7$

$Q = \sqrt{3 \cdot 7} = 4.58$

$\frac{C}{I} = 18.66\,dB$ (Maior que pedido!)

$n = 3$ $\quad \frac{C}{I} = 15\,dB = 10\log_{10}\left(\frac{1}{6}\sqrt{3N}^n\right)$

$N = \frac{\left(6 \cdot 10^{1.5}\right)^{\frac{2}{3}}}{3} = 11 \Rightarrow N = 12$

$Q = \sqrt{3 \cdot 12} = 6$

$\frac{C}{I} = 15.56\,dB$ (Maior que pedido!)

3.4) $n = 3$

$P_R(d = 1m) = 1mW \Rightarrow P_R = 1mW\left(\frac{d}{1}\right)^{-n}$

$P_{R_I} < -100\,dBm$

Para $d = D$ queremos $I < -100\,dBm$ logo:

$P_R = d^{-n} \times 10^{-3}\,W$

$P_{R_i} = 10^{-13}\,W$

$\frac{C}{I} = \frac{P_R}{x \cdot P_{R_i}} = \frac{R^{-n}}{x \cdot D^{-n}} \Rightarrow \frac{P_R}{P_{R_i}} = \sqrt{3N}^n \Rightarrow R = \frac{10^{\frac{10}{n}}}{\sqrt{3N}}$

x = Estação que interferem

a) $N = 7$

$R = 470\,m$

b) $N = 4$

$R = 621\,m$

3.5 $A_u = 0.1E$

$QoS = GoS = B = 0.5\%$

a) $C = 1 \Rightarrow A_T = 0.005E \Rightarrow U = \left\lfloor \frac{A_T}{A_u} \right\rfloor = 0$

b) $C = 5 \Rightarrow A_T = 1.13E \Rightarrow U = 11$

c) $C = 10 \Rightarrow A_T = 39.6E \Rightarrow U = 39$

d) $C = 20 \Rightarrow A_T = 11.1E \Rightarrow U = 111$

e) $C = 100 \Rightarrow A_T = 80.9E \rightarrow U = 809$

3.6) $u = 2 \times 10^6$ pessoas

A: N-Cells = 394 C = 19

B: N-Cells = 98 C = 57

C: N-Cells = 49 C = 100

$B = 2\%$

2 chamadas por hora duração de 3 min $\Rightarrow A_u = \frac{2 \times 3}{60} = 0.1E$

A $\rightarrow$ A_T por célula = 12.3E $\rightarrow$ u por célula = 123

$u_A = 48462$ $MP = \frac{u_A}{u} \times 100 = 2.4\%$

B $\rightarrow$ A_T por célula = 46.8E $\rightarrow$ u por célula = 468

$u_B = u$ por célula $\times$ N° Cell = 45864 $MP = \frac{u_B}{u} \times 100 = 2.3\%$

C $\rightarrow$ A_T por célula = 88.0E $\rightarrow$ u por célula = 880

$u_C = 43120$ $MP = 2.2\%$

3.7) $A_{city} = 1300$ sqm miles

7 cell reuse factor

$R = 4$ miles

$B_T = 40$ MHz

$B_{ch} = 60$ KHz

$B = 2\%$

$A_u = 0.03E$

a) $A_{\hexagon} = 6 \times \frac{R \times \sqrt{R^2 - \frac{R^2}{4}}}{2} = 3R \times \sqrt{\frac{3R^2}{4}} = \frac{3\sqrt{3}}{2} R^2 = 24\sqrt{3}$ sqm miles

N-Cells $= \frac{A_{city}}{A_{\hexagon}} = 31.2 \Rightarrow 32$ ✓

b) $N\,Canais_t = \frac{B_T}{B_{ch}} = 666.7$

$C = \frac{666.7}{7} = 95$

c) A_T por célula = 83.1E

d) $A_{Max} = A_T$ por célula $\times$ N° cells = 2659E

$A_{Max}\ corrigido = (1-B) \cdot A_{Max} = 2606E$

e) $u = \frac{A_{Max}}{A_u} = 88640$

f) N° mobiles por channel $= \frac{u}{N_{Canais_t}} = 133.1$

g) $u_{max} =$ N-channels per cell $\times$ N-cells = 3040

3. 9) $f_c = 1800\,MHz$

Va Sys - 40%

$R_B = 750\,kbit/s$

20 Time Slots

108 data bits

a) 9 channels

$R_{B\,util} = \frac{108}{183} \cdot \frac{750\,K}{20} = 22.13\,K\,bit/s$

Voz: $40\% \times 8\,K\,bit/s \rightarrow 3.2\,K\,bit/s$

$\frac{3.2\,K}{22.13\,K} \times 100 = 15$ Time Slots

Data: $10 \times \frac{144\,K}{22.13\,K} = 65\,TS$

Vídeo: $1 \times \frac{1M}{22.13K} = 46\,TS$

Total = 15 + 65 + 46 = 126 TS

$126 < 180 \Rightarrow$ Funciona

Time slots disponíveis = 9 × 20 = 180 TS

b) $\mu = 3500$

$\nu = 0.15$

$H = 1.5\,min = \frac{1.5}{60}\,h$

$B = 2\%$

$A_\mu = \mu H = 3{,}75 \times 10^{-3}\,E$

$A_{need} = A_\mu \cdot \mu = 13{,}125\,E$

Ondio (40%): Nº médio de TS por canal = $\frac{32K \cdot 0{,}4}{22.13\,K} = 0.579\,TS/channel$

Temos de cumprir 2 condições:

B = 2% e 20 canais

Pela tabela B = 2% e C = 20 $\Rightarrow A_{offer} = 13.2\,E$ Como $A_{offer} > A_{need}$, rede funciona!

Temos time slots suficientes??

20 channels · 0.579 TS/channel = 11.58 TS $\Rightarrow$ Temos 20 TS disponíveis → Funciona //