3-15 (a) Given $GOS = 2\%$

For $C = 4$ channels, from the Erlang B chart

$A_{total} \doteq 1.1$ Erlangs $\Rightarrow A_{per\,channel} = \frac{A_{tot}}{C} = 0.275$ Erlangs

For $C = 20$ channels.

$A_{total} \doteq 14$ Erlangs $\Rightarrow A_{per\,channel} = \frac{14}{20} = 0.7$ Erlangs

For $C = 40$ channels

$A_{total} \doteq 31$ Erlangs $\Rightarrow A_{per\,channel} = \frac{31}{40} = 0.775$ Erlangs

(b) $U = \frac{A_{total}}{\mu \cdot H} = \frac{31}{\frac{1}{3600} \times 105} \doteq 1063$ users

(c) For $C = 4$ channels, $A_{total} = 1.1$ Erlangs, $H = 105$ seconds/call.
from the Erlang C chart, we have

$Pr[\text{delay} > 0] \doteq 0.03$

$\Rightarrow Pr[\text{delay} > 20\,\text{sec}] = Pr[\text{delay} > 0] \cdot \exp[-(C - A_{total}) \cdot 20\,\text{sec}/H]$

$= 0.03 \times \exp[-(4-1.1) \times 20/105] \doteq 0.017$

3-15 Cont'd

For $C = 20$ channels. $A_{total} = 14$ Erlangs, we have

$Pr[\text{delay} > 0] \doteq 0.06$

$\Rightarrow Pr[\text{delay} > 20\,\text{sec}] = Pr[\text{delay} > 0] \cdot \exp[-(C - A_{total}) \cdot 20\,\text{sec}/H]$

$= 0.06 \times \exp[-(20-14) \times 20/105] \doteq 0.019$

For $C = 40$ channels. $A_{total} = 31$ Erlangs, we have

$Pr[\text{delay} > 0] \doteq 0.07$

$\Rightarrow Pr[\text{delay} > 20\,\text{sec}] = 0.07 \times \exp[-(40-31) \times 20/105] \doteq 0.013$

(d) From (c) we can see that the probability that a call will be delayed for more than 20 seconds in a lost call delayed system is less than 2% for all the different channel numbers. Thus a lost call delayed system perform better than a system that drops blocked calls.

3-16 For 7 cell reuse pattern, the interference signal power from another transmitter is

$$P_I = P_t \cdot \left(\frac{D}{d_0}\right)^{-n} = P_t \cdot \left(\frac{\sqrt{3N} \cdot r}{d_0}\right)^{-n}$$

Where P_t is the transmit power in base station, D is the distance to the center of the nearest co-channel cells, r is the major radius. In this case, $P_t = 1\,\text{mW}$, $N = 7$, $d_0 = 1\,\text{m}$, $n = 3$, thus we have

3-16 Cont'd

$$10\log_{10}\frac{P_t\cdot\left(\frac{\sqrt{3N}\cdot r}{d_0}\right)^{-n}}{1mW} < -100\,dBm$$

$$\Rightarrow 10\log_{10}\frac{1mW\times\left(\frac{\sqrt{3\times7}\cdot r}{1m}\right)^{-3}}{1mW} < -100\,dBm \Rightarrow \underline{\underline{r > 470.1\,m}}$$

<u>For 4 cell reuse pattern.</u> $N=4$, we have

$$10\log_{10}\frac{1mW\times\left(\frac{\sqrt{3\times4}\cdot r}{1m}\right)^{-3}}{1mW} < -100\,dBm \Rightarrow \underline{\underline{r > 621.9\,m}}$$

3.23 Cont'd

(b) $SNR = -90-(-111) = \underline{\underline{21\,dB}}$

(c) $SNR = -90-(-119.2) = \underline{\underline{29.2\,dB}}$

(d) $SNR = -90-(-101.6) = \underline{\underline{11.6\,dB}}$

(e) $SNR = -90-(-103.1) = \underline{\underline{13.1\,dB}}$

(f) $SNR = -90-(-114) = \underline{\underline{24\,dB}}$

3.22 (a) For AMPS, the channel bandwidth $B_W = 30KHz$

Given noise figure $F = 10dB = 10$, we have

noise floor $= K \cdot B_W \cdot F \cdot T_0$, where K is Boltzman constant, $T_0 = 290°K$

$\Rightarrow$ noise floor $= 1.38 \times 10^{-23} \times 30 \times 10^3 \times 10 \times 290$

$\doteq 1.2 \times 10^{-15}\ (W) \doteq -119.2\ (dBm)$

(b) For GSM, $B_W = 200KHz$

$\Rightarrow$ noise floor $= K \cdot B_W \cdot F\ T_0 = 1.38 \times 10^{-23} \times 200 \times 10^3 \times 10 \times 290$

$\doteq 8 \times 10^{-15}\ (W) \doteq -111\ (dBm)$

(c) For USDC, $B_W = 30KHz$

$\Rightarrow$ noise floor $= -119.2\ (dBm)$

(d) For DECT, $B_W = 1.728\ MHz$

$\Rightarrow$ noise floor $= -101.6\ (dBm)$

(e) For IS-95, $B_W = 1.2288\ MHz$

$\Rightarrow$ noise floor $= -103.1\ (dBm)$

(f) For CT-2, $B_W = 100KHz$

$\Rightarrow$ noise floor $= -114\ (dBm)$

3.23 (a) SNR = signal level (dBm) − noise floor (dBm)

$= -90 - (-119.2) = 29.2\ dB$

$\boxed{3.29}$ (a) Given loan $= \$6\times10^6$, Cost of MTSO, $C_{MTSO} = \$1.5\times10^6$. Cost of a base station, $C_{bs} = \$5\times10^5$, Cost of advertisement, $C_{ad} = \$5\times10^5$, we have,

the number of the base stations we are able to install,

$$N = \frac{loan - C_{MTSO} - C_{ad}}{C_{bs}} = \frac{6\times10^6 - 1.5\times10^6 - 5\times10^5}{5\times10^5} = \underline{\underline{8}}$$

(b) Given $N = 8$ cells, total coverage area $A_{tot} = 140\,Km^2$.

$\Rightarrow$ coverage area of each cell $A_{each} = \frac{A_{tot}}{N} = \frac{140}{8} = \underline{\underline{17.5\,km^2}}$

Since $A_{each} = 2.6R^2$, we have

$$R = \sqrt{\frac{A_{each}}{2.6}} = \sqrt{\frac{17.5}{2.6}} \doteq \underline{\underline{2.6\,km}}$$

(c) For each year, each customer will pay $P = 50\times12 = \$600$.

Assume the number of customers on the first day of service is M, the gross billing revenus by the end of the fourth year of operation is

$$G = (M + 2M + 4M + 8M)\cdot P = 15M\cdot P$$

We need $G \geq \$10\times10^6 \Rightarrow 15MP \geq 10\times10^6$

$$\Rightarrow M \geq \frac{10\times10^6}{15\cdot P} = \frac{10\times10^6}{15\times600} \doteq 1111.1.$$

Hence the minimum number of customer on the first day of service is $\underline{\underline{1112}}$

(d) number of users per square Km $= \frac{M}{A_{tot}} = \frac{1112}{140} \doteq \underline{\underline{8\ \text{users}/Km^2}}$