PCS. - Propagation G. finals.

1) Consider a host of panning coverage in a dense urban area. The following data are known:

- \( L_0 = 120 \text{ dB} \)
- \( d_0 = \text{true} \)
- \( h = 43 \text{ dB} / \text{d} \)
- \( \sigma = 9 \text{ dB} \)
- \( L_p = 25 \text{ dB} \)
- \( E_{pl} = 9 \text{ dB} \)
- \( Q = 90\% \)
- \( \sigma \text{std. deviation of propagation losses.} \)
- \( \sigma \text{aica reliability.} \)

a) Calculate composite standard deviation:

\[
\sigma_c = \sqrt{\sigma^2 + \sigma^2} = 11.40 \text{ dB}
\]

b) Determine path variance for in-building and outdoor coverage:

- \( \sigma_{in} = 11.40 / 3 = 2.45 \)

\[
2 \text{- score } = 0.75
\]

\[
F_{in} = 0.75 \times 11.40 = 8.55 \text{ dB}
\]

- \( \sigma_{out} = 9 / 3 = 3.00 \)

\[
2 \text{- score } = 0.46
\]

\[
F_{out} = 0.46 \times 9 = 5.36 \text{ dB}
\]

o) If \( S_{in} = 50 \text{ dBm}, \ RSL = -100 \text{ dBm} \) determine difference between cell radii.

- For outdoor and in-building coverage, Body loss is 20 dB.

In building:

\[
\begin{align*}
\text{RSL}_b &= \text{RSL} + 2L + L_p + F_H = -100 + 12 + 25 + 85 + 85 \\
\text{PSU} &= -64.97 \text{ dBm}
\end{align*}
\]
\[ PL_b = 50 + 20 \log_10(d/10) \]

\[ 114.45\,\text{dB} = 120\,\text{dB} + 43\log_10(d/10) \Rightarrow d = 0.74\,\text{miles} \]

**Solution:**

\[ RSL_b = RSL_g + 20 + PL_b = -160\,\text{dBm} - 2\,\text{dB} + 58.5\,\text{dB} = -92.15\,\text{dBm} \]

\[ PL_b = 50 + 20 \log_10(-92.15) = 142.11\,\text{dB} \]

\[ 114.15\,\text{dB} = 120\,\text{dB} + 43\log_10(d/10) \Rightarrow d = 0.77\,\text{miles} \]

**d)** Compare coverage areas of cells providing indoor and outdoor coverage.

\[
\begin{align*}
\text{Indoors:} & \quad \frac{0.74^2}{3.9^2} = \frac{1.72}{88.6} = 0.02\%
\end{align*}
\]

This illustrates difficulty of covering dense urban areas. A transmission from an outdoor cell 1 mile away, but is providing reliable coverage only 0.7 miles away. The answer is to provide full in-building coverage that within buildings in a manner similar to GSM.

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**2. Consider the situation depicted in Fig.** The adjacent channel overlap of the GSM mobile phone is 15dB. Calculate the aggregate CA noise for the mobile.

**Case 1:**

- \[ F_1 \]
  - Frequency: 11
  - EIRP: 50dBm
  - PL: 110dB

**Case 2:**

- \[ F_2 \]
  - Frequency: 9
  - EIRP: 50dBm
  - PL: 110dB

**Case 3:**

- \[ F_3 \]
  - Frequency: 10
  - EIRP: 50dBm
  - PL: 180dB

Using \[ K_f = 4 \times 10^{-12} \text{W/m} \text{Hz} \]

**Frequency:** 7dB

**Bandwidth:** 200 kHz

Calculate for mobile.
\( C = \text{ERP}_s - \text{PL}_s = 50 \text{dBm} - 100 \text{dB} = -50 \text{dBm} \)

\( I_1 = \text{ERP}_I - \text{PL}_I = 50 \text{dBm} - 110 \text{dB} = -60 \text{dBm} \)

\( I_2 = \text{ERP}_I - \text{PL}_2 = 50 \text{dBm} - 110 \text{dB} = -60 \text{dBm} \)

\( I_3 = \text{ERP}_I - \text{PL}_3 = 50 \text{dBm} - 120 \text{dB} = -70 \text{dBm} \)

\[ \text{filter} \text{ } \text{low} \text{ } \text{pass} \text{ } \text{cutoff} \text{ } \text{frequency} \text{ } \text{rejects} \text{ } \text{adjacent} \text{ } \text{channels} \]

\[ I_{1A} = I_1 - A\text{ERP}_B = -60 \text{dBm} - 12 \text{dB} = -72 \text{dBm} \rightarrow 1.5 \times 10^{-8} \text{mW} \]

\[ I_{2A} = I_2 - A\text{ERP}_B = -60 \text{dBm} - 12 \text{dB} = -72 \text{dBm} \rightarrow 1.58 \times 10^{-8} \text{mW} \]

\[ I_{1B} = I_3 = -80 \text{dBm} \rightarrow 1 \times 10^{-8} \text{mW} \]

\[ \frac{C}{I} = \frac{C}{I_{1B}} = 10 \log \left[ \frac{10^{-5} \text{mW}}{2 \times 1.58 \times 10^{-8} \text{mW} + 1 \times 10^{-8} \text{mW}} \right] = 23.8 \text{dB} \]

\[ N = kT B W F = 4 \times 10^{-15} \frac{\text{W}}{\text{Hz}} \cdot 200 \times 10^6 \text{Hz} \cdot 10^{0.7} = 4 \times 10^{-9} \text{mW} \]

\[ \frac{C}{F+1} = 10 \log \left[ \frac{10^{-5} \text{mW}}{2 \times 1.58 \times 10^{-8} \text{mW} + 1 \times 10^{-8} \text{mW} + 4 \times 10^{-9} \text{mW}} \right] = 23.4 \text{dB} \]

\[ 3 \] Consid a 6000 MHz system on the remote link. The following data are known. \( B W = 1.3 \text{ MHz} \)

\( F = 5 \text{ dB} \), \( kT = 4 \times 10^{-14} \text{W} / \text{K} \)

\( R_c = 1.2288 \times 10^5 \text{ bauds/Hz} \), \( R_b = 9.2 \times 10^2 \text{ bps/sec} \), \( E_b / N_0 = 5 \text{ dB} \)

\( \text{NR} [\text{dB}] = 3 \text{ dB} \)

a) Calculate the power of the wanted signal received at the basic station.
b) \( P_{L_0} = 109 \text{ dBm}, M = 38.8 \text{ dB/mile}, P_{Rx} = 28 \text{ dBm} \), calculate the downlink cell radius when the NF changes between 2 and 6 dB.

\[
\text{a)} \quad \frac{P_{L_0}}{N_0} = \frac{P_{Rx} R_c}{PL_{2n}}
\]

\[
P_{Rx} = \frac{P_{L_0}}{N_0} \times \text{KTB} \times \text{ND} \times \frac{P_o}{R_c}
\]

\[
\frac{P_{L_0}}{N_0} = 5 \text{ dB} \rightarrow 3.16 \quad \text{NF} = \text{KTB} = 4 \times 10^{-2} \text{ W/m}^2 \times 1.6 \times 10^6 \text{ Hz} \times 10^3
\]

\[
10^2 = 1.64 \times 10^{-11} \text{ W} \rightarrow -167.8 \text{ dBm}
\]

\[
P_{Rx} = 3.16 \times 1.64 \times 10^{-11} \text{ W} \times 2 \cdot 9.6 \times 10^3 / 1.288 \times 10^6 = 2.09 \times 10^{-12} \text{ W} \rightarrow -120.9 \text{ dBm}
\]

Note: \( P_{Rx} < \text{NF} \), \( P_o = -120.9 \text{ dBm} \) \( \Rightarrow \) one does not "see" receiver link \( \text{NF} = -107.8 \text{ dBm} \) \( \Rightarrow \) transmission is obscured by noise.

\[\text{b)} \quad \text{NR} = 2 \text{ dB}; \]

\[
P_{Rx} = 3.16 \times 1.64 \times 10^{-11} \text{ W} \times 10^3 \cdot 9.6 \times 10^3 / 1.288 \times 10^6 = 6.91 \times 10^{-12} \text{ W} \rightarrow -120.9 \text{ dBm}
\]

\[
\text{PL}_{-2} \text{ dB} = P_{Rx} - P_{Rx} = -2.5 \text{ dBm} - (-12.1 \text{ dBm}) = 144.9 \text{ dB}
\]

\[
144.9 \text{ dB} = 10^9 + 20 \log (d/d_0) \Rightarrow d = 8.6 \text{ miles}
\]

\[\text{NR} = 6 \text{ dB}; \]

\[
P_{Rx} = 3.16 \times 1.64 \times 10^{-11} \text{ W} \times 10^3 \cdot 9.6 \times 10^3 / 1.288 \times 10^6 = 1.6 \times 10^{-12} \text{ W} \rightarrow -117.9 \text{ dBm}
\]

\[
\text{PL}_{-6} \text{ dB} = P_{Rx} - P_{Rx} = 23 \text{ dBm} - (-117.9 \text{ dBm}) = 140.9 \text{ dBm}
\]

\[
140.9 \text{ dBm} = 10^9 + 20 \log (d/d_0) \Rightarrow d = 6.77 \text{ miles}
\]
Area comparison: \[
\frac{A_{10E-2}}{A_{10E-6}} = \left( \frac{8.6}{6.77} \right)^2 = 1.62
\]

4. The cellular bands in two scales are given as:

\[ A_1 = 10E \quad A_2 = 20E \]

Calculate \[ A_{2x}/A_{50\%} \] in the two cells. Value \( A_{50\%} \) represents the hollow exceeded in \( 50\% \) of the time.

Traffic exceeded in \( 50\% \) of time may be calculated using \( E_b \) table:

\[ E_b [A_{load}, G_{55}=55\%] \rightarrow A_{50\%} \]

cell 1: \[
A_{50\%} = E_b [A=10E, G_{55}=55\%] = 6E
\]

\[
A_{2x} = E_b [A=10E, G_{55}=20\%] = 17E
\]

\[ A_{2x}/A_{50\%} = \frac{17E}{6E} = 2.83 \]

cell 2: \[
A_{50\%} = E_b [A=20E, G_{55}=50\%] = 11E
\]

\[
A_{2x} = E_b [A=20E, G_{55}=20\%] = 28E
\]

\[ A_{2x}/A_{50\%} = \frac{28E}{11E} = 2.54 \text{ smaller, not cell 1.} \]
A distribution of interarrival time for a process is given by

$$PDF(t) = \frac{1}{T} \exp\left(-\frac{t}{T}\right), \quad t \geq 0, \text{ and } T = 12 \text{ seconds}$$

Determine the probability of experiencing more than 4 arrivals/minute.

1) If the average call holding time is 20 seconds, estimate the offered load in Erlangs. Distribution of CHT is exponential.
2) If the process is served using the G/G/1 system of the type M/M/1, determine

1) Probability of a request being placed in the queue.
2) The average delay for users that are placed in the queue.
3) The average size of the queue.

1. The average interarrival time is $T = 12$ seconds. The average arrival rate is
   $$\lambda = \frac{1}{T} = \frac{1}{12} \text{ min}^{-1} = 5 \text{ arrivals/minute}$$

   The process is the Poisson process.

   $$\Pr(X = k) = \left(\frac{\lambda t}{k!}\right) \exp(-\lambda t)$$

   $$\Pr(X \leq 4) = \sum_{k=0}^{4} \left(\frac{(5t)^k}{k!}\right) \exp(-5t) = \sum_{k=0}^{4} \left(\frac{(5 \times 1)^k}{k!}\right) \exp(-5 \times 1) = 0.44$$

2. $CHT = 30 \text{ sec} \rightarrow \frac{1}{\mu} = \frac{1}{30 \text{ sec}} = \frac{1}{0.5 \text{ min}} = 2 \text{ min}^{-1}$

   $$\alpha = \frac{c}{\mu} = \frac{3}{2} = 1.5$$

3. $N/M/C \rightarrow$ Erlang C model

   Service utilization $\rho = \frac{a}{c} = \frac{2.5}{5} = 0.5$
\[ P_r(>0) = \frac{a^c}{c! (1-s)} = \frac{0.5^c}{5! (1-0.5)} = 0.1304 \]

\[ \sum_{k=0}^{c} \frac{a^k}{k!} + \frac{a^c}{c! (1-s)} = \sum_{k=0}^{c} \frac{0.5^k}{k!} + \frac{(2.5)^c}{c! (1-0.5)} \]

1) \[ D_1 = P_r(>0) \cdot \frac{\text{CHI}}{c-a} = \frac{0.1304 \times 80 \text{sec}}{5-2.5} = 1.864 \text{ sec} \]

\[ D_0 = \frac{\text{CHI}}{c-a} = \frac{30}{5-2.5} = 12 \text{ seconds.} \]

2) \[ L_0 = P_r(>0) \cdot \frac{a}{c-a} = \frac{0.1304 \times 2.5}{5-2.5} = 0.1304 \]

Test mode: Comprehensive
Closed book, closed notes, formula sheet allowed.
Expect 5-6 problems.
90+ is A.