Personal Communication Systems (Lecture 15)

Preparation for finals

Materials included on the test:

* Coverage planning
  - edge reliability
  - area reliability
  - path loss calculations
  - link budget analysis

* QoS
  - channel limitations
  - channel bandwidth

* Capacity Planning
  - frequency reuse
  - Erlang B formula
  - Erlang C formula

Test is Tuesday 8:30 AM - 10:30 AM

Time: 120 mins

Media: open book/open notes

II Problems: 3-4 problems

Grading scheme:

<table>
<thead>
<tr>
<th>Score</th>
<th>Grade</th>
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<tbody>
<tr>
<td>&gt;90</td>
<td>A</td>
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<tr>
<td>80-89</td>
<td>B</td>
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<tr>
<td>70-79</td>
<td>C</td>
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<tr>
<td>60-69</td>
<td>D</td>
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<tr>
<td>&lt;60</td>
<td>F</td>
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Problem: Stream design needs to provide 95% reliability at in-vehicle coverage. The following data are known:

- Propagation model: standard deviation: 8 dB
- Vehicle noise in the city: 2 dB
- Vehicle penetration loss: 7 dB
- Minimum required RSL: -130 dBm
- Cell site ERP: 47 dBm
- Cell site height: 150 feet
- MS height: 6 feet

Propagation is modeled using the model with slope of 37.2 dB/decade, \( P_{ref}(d) \) = 16 dB.

d is the reference distance at \( d = 1 \) mile.

a) Calculate composite standard deviation

\[
\sigma_{cp} = \sqrt{\sigma_{ex}^2 + \sigma_{pm}^2} = \sqrt{8^2 + 2^2} = 8.544
\]

b) Calculate the far zone

\( k = 3.7 \)

\( \theta_0 = 8.544 / 3.7 = 2.31 \)

\( \beta \) = 0.651

RM = 0.651 \times 8.544 = 7.27 dB

c) Determine win RSL outside of city:

\( P_{swin} = -100 \log(\frac{d}{3.7}) - 7.27 + 7.27 = -85.72 \) dBm

d) Determine win cell RSL in urban environment

\( P_{swin} = E20 - 25 \log(d) - 7.27 - (-85.72) = 12.73 \) dB
\[ PL(d) = 10 \log(87.30 d^0.3) - 15 \log\left(\frac{100}{200}\right) - 10 \log(10) \]

R(haut) = P(haut)

Therefore

\[ 10 \log(87.30 d^0.3) = 6 \]

Predicted

**Consider a typical scenario:** 15-155, as per

The network is operated using frequencies 15-155. The parameters at 15-155 are:

- Bandwidth: 8 MHz
- Bandwidth utilization: 60%
- Noise added to the signal: 30 dB
- Power loss expected: around 29 dB

**Table:**

| Bandwidth | Noise | Power Loss | Loss
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<thead>
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<tbody>
<tr>
<td>8 MHz</td>
<td>60%</td>
<td>30 dB</td>
<td>29 dB</td>
</tr>
</tbody>
</table>

1) Calculate the number of **1 MHz channels**

\[ \text{Number of channels} = \frac{155 - 15}{2} = 70 \]

2) **Per sector:**

\[ \text{Number} = \frac{60}{15} = 4 \text{ channels/sector} \]

3) **What is the capacity of each channel expressed in Ghz?**

\[ 4 \text{ channels} = 4 \times 1.88 = 15.5 \text{ Ghz/channel} \]

4) **Total:**

\[ A [\text{GHz} = 41.65 - 2.97 = 38.7 \text{E} \]

5) **Punkt wants to introduce new technology:**

**Estimate how much spectrum can be shared.**

- Repeat scheme is changed from 15-12 to 12-7
- The 15-185 needs to maintain the same capacity.
A = 21.9 E \Rightarrow \# \text{ hins} = 41 \Rightarrow \text{number of hins}/\text{solar} = 13.671 \times 41

One radio \Rightarrow \text{one channel}.

\text{where: } \frac{\text{U}}{21} \text{.Client number of channels can be calculated as:}

\text{U} = (14 \times 3) \times 7 = 294 \text{ channels}

\text{Specific around for 294 channels:}

\text{Pr, high} = 294 \times 20 + 2 \times 20 = 8880 \text{ W } \Rightarrow 8.88 \text{ Hz}

\text{Specific around for modulation of G641:}

\text{Pr, low} = 15 \text{ Hz} - 8880 \text{ Hz} = 6.12 \text{ Hz}

\text{1.} \text{ Example: determination of the worst case C/I for IS-136G network:}

\text{C/I} = \frac{1}{6} (N \sqrt{2})^2

\text{N = 12: } \text{C/I} = \frac{1}{6} (N \sqrt{2})^2 = 216.00 = 23.3 \text{ dB}
1. \( C/1 = \frac{1}{2} (\sqrt{N+1})^4 = 73.5 \rightarrow 18.4 \text{ dB} \)

\( \Delta C_2 = C/1 (u+1) - C/1 (u+1) = 4.64 \text{ dB} \)

e) From above, GCI channels can be incorporated in the selectivity of the receiver.

GCI pattern: 81:2:81

TMA: 2 ums, 3 channels

GCI = 2 dB.


2. Problem: Include influence of GGI channels and a power 5 channels.

3. Problem: Consider 3 layers, 4 1/2 plan.

4. Problem: 91:2, 2 channels at 51/2 plan.

5. Problem: What is additional capacity provided to sector \( (81+2) \)

\# GCI tanks = \( 2 \times 8 = 16 \) /sector

At GCI = 91, 0 = 16 \( \Rightarrow A = 9.86 \text{ E} \)

Capacity increase: \( 31.99 \rightarrow 15-186 \) only \( (N=12) \)

\( 31.99 \text{ E} (15-186) + 9.82 \text{ E GCI, + additional capacity from new one.} \)

Problem 3: Consider the situation depicted in Fig. Calculations

a) 9-channel minimum

b) 31-channel minimum

c) total imbalance

d) aggregate GCI GCI, decrease all channels above, and \( \Delta C_2 = 18 \text{ dB} \)
Serial Site

- Channel 2
  - ERP: 30 dBm
  - PL: 127 dB

- Channel 3
  - ERP: 47 dBm
  - PL: 123 dB

- Channel 4
  - ERP: 52 dBm
  - PL: 188 dB

- Channel 5
  - ERP: 49 dBm
  - PL: 140 dB

a) Co-channel interference

\[ I_{cc} = 49 \text{ dBm} - 140 \text{ dB} = -91 \text{ dBm} \]

b) Adj-channel interference

\[ I_{ac1} = 47 \text{ dBm} - 127 \text{ dB} = -80 \text{ dBm} \]
\[ I_{ac2} = 50 \text{ dBm} - 135 \text{ dB} = -85 \text{ dBm} \]
\[ I_{ac} = 10 \log \left( 10^{0.124} + 10 \right) \text{ dBm} \]
\[ = 10 \log \left( 10^{0.124 + 10} \right) \text{ dBm} \]
\[ = -79.36 \text{ dBm} \]

c) \[ I_{mix} = 10 \log \left( 1 \right) + 10 \text{ log} \left( I_{ac} - I_{cc}\text{ dBm} \right) \]
\[ I_{\text{ref}} = 10^{0.1 \times (-91)} + 10^{(-74.85 - 10)} = 9.77 \times 10^{-10} \text{ W} \]

\[ I_{\text{ref [dBm]}} = -90.09 \text{ dBm} \]

c) Echelle du plan

\[ G = E_0 \text{ dBm} - 13.5 \text{ dB} = -75.25 \text{ dBm} \]

\[ G/T = -75.25 \text{ dBm} - (-70.94 \text{ dBm}) = 15.09 \text{ dB} \]