Homework

Received power at 10 m = 100mW
Receiver threshold = -50 dBm
Propagation factor $\eta = 3.7$
Log-normal shadowing with $\sigma_{dB} = 4$ dB
Fading margin $M = 6$ dB

**Cell Radius $R =$ ?**

\[
P_R(R)_{[dBm]} = P_R(d_0)_{[dBm]} - 10\eta \log_{10} \left( \frac{R}{d_0} \right) = P_{th} + M
\]

\[
20 - 37 \log_{10} \left( \frac{R}{10} \right) = -50 + 6
\]

\[
R = 10 \cdot 10^{\frac{64}{37}} = 537 \text{ m}
\]
Problem 1

Let us assume an internet service provider (ISP) with 1000 users, wherein each user uniformly starts 1.5 internet sessions per day. Each session lasts 45 minutes so as to generate 10000 bit packets with an average frequency of 30 pkts/minute over 50 kb/s channels. Please calculate the following

1. average number of active sessions
Problem 1

The average number of active sessions $E[N]$ is obtained using the Little’s Formula

$$E[N] = \lambda E[T]$$

where the session frequency is $\lambda = \frac{1000 \times 1.5}{24}$ sessions/hours

and the average duration of a single session is $E[T] = \frac{3}{4}$ hours

It yields that

$$E[N] = 46.9$$
Problem 1

Let us assume an internet service provider (ISP) with 1000 users, wherein each user uniformly starts 1.5 internet sessions per day. Each session lasts 45 minutes so as to generate 10000 bit packets with an average frequency of 30 pkts/minute over 50 kb/s channels. Please calculate the following

2. average number of transmitted packets (simultaneously)
Problem 1

The average transmission time for a single packet can be calculated as \( T_p = \frac{10000 \text{ bits}}{50 \text{ kb/s}} = 200 \text{ ms} \)

We can derive the average number of packets for each single session using the Little’s formula, as follows

\[
E[S] = \lambda_p E[T_p] = 0,5 \frac{pkts}{s} \times T_p = 0,1
\]

Therefore \( E[S] = 46,9 \times 0,1 = 4,69 \) packets transmitted simultaneously
Problem 1

Let us assume an internet service provider (ISP) with 1000 users, wherein each user uniformly starts 1.5 internet sessions per day. Each session lasts 45 minutes so as to generate 10000 bit packets with an average frequency of 30 pkts/minute over 50 kb/s channels. Please calculate the following

3. the average burstiness factor.
Problem 1

Recalling that each session lasts 45 minutes, we may calculate that on average we have 1,5 sessions per day. It yields that

\[ T_{ON} = 45 + 22,5 = 67,5 \text{ minutes} \]
\[ T_{OFF} = 1440 - 67,5 = 1372,5 \text{ minutes} \]

Therefore, the burstiness factor is

\[ \frac{T_{ON}}{T_{ON} + T_{OFF}} = \frac{67,5}{1440} = 4,6\% \]
Problem 2

Let us assume a CDMA cellular system with processing gain of 200 and a minimum $\frac{E_b}{N_0} = 10\,\text{dB}$. Please calculate the uplink capacity, i.e., the number of voice calls, when

1. there is a single cell and no silence suppression for voice coding;
Problem 2

We need to recall the following formula

\[ \eta_{MAX} \approx 1 + \frac{G_p}{\left(\frac{E_b}{N_0}\right)_{min}} = 1 + \left(\frac{200}{10}\right) = 21 \]
Problem 2

Let us assume a CDMA cellular system with processing gain of 200 and a minimum $\frac{E_b}{N_0} = 10\text{dB}$. Please calculate the uplink capacity, i.e., the number of voice calls, when

2. there is a voice activity factor equal to 0:35;
Problem 2

We need to recall the following formula

\[ \eta_{MAX} \cong 1 + \frac{1}{v_f} \frac{G_p}{(E_b/N_0)_{min}} = 1 + \left( \frac{1}{0.35} \frac{200}{10} \right) \cong 58 \]
Problem 2

Let us assume a CDMA cellular system with processing gain of 200 and a minimum $\frac{E_b}{N_0} = 10$ dB. Please calculate the uplink capacity, i.e., the number of voice calls, when

3. there is a multiple cell scenario with inter-cell interference equal to 60% of intra-cell interference.
Problem 2

We need to recall the following formula

\[ \eta_{MAX} \approx 1 + \frac{1}{\nu_f (1 + f) \left( \frac{E_b}{N_0} \right)_{min}} = 1 + \left( \frac{1}{0.35 \times 1.6} \frac{200}{10} \right) \approx 35 \]
Problem 3

Design the multiplexing scheme of a TDMA mobile radio system. The system has radio carriers with a rate of 320 Kb/s and it requires the following logical channels:

- Traffic channels TCH (uplink and downlink) with rate 35 Kb/s
- Associated control channels SACCH (uplink and downlink) with rate 5 Kb/s
- Broadcast channel BCCH (only downlink) with rate 10 Kb/s
- Frequency channel FCCH (only downlink) with rate 2 Kb/s
- Synchronization channel SCH (only downlink) with rate 4 Kb/s
- Paging channel PCH (only downlink) with rate 14 Kb/s
- Access grant channel AGCH (only downlink) with rate 6 Kb/s
- Random access channel RACH (only uplink) with rate 38 Kb/s

On a carrier you have to multiplex 7 TCHs and their 7 SACCHs and one signaling channel for each of the types indicated above. Design the multiplexing scheme indicating the frame and multi-frame structure for both uplink and downlink.
Problem 3

We need to schedule 7 TCH + 1 SACCH. Therefore we need to transmit within one frame at least 40 Kb/s.

We have \(\frac{320}{40} = 8\) slots per frame.

Multi-frame with 8 frames

Signaling channels with multi-frame including 20 frames.

<table>
<thead>
<tr>
<th>Frame 1</th>
<th>TCH1</th>
<th>TCH2</th>
<th>TCH3</th>
<th>TCH4</th>
<th>TCH5</th>
<th>TCH6</th>
<th>TCH7</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame 2</td>
<td>TCH1</td>
<td>TCH2</td>
<td>TCH3</td>
<td>TCH4</td>
<td>TCH5</td>
<td>TCH6</td>
<td>TCH7</td>
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<tr>
<td>Frame 8</td>
<td>SACCH1</td>
<td>SACCH2</td>
<td>SACCH3</td>
<td>SACCH4</td>
<td>SACCH5</td>
<td>SACCH6</td>
<td>SACCH7</td>
<td>S</td>
</tr>
</tbody>
</table>

Slot 8 DL: B B B B B F S S P P P P P P A A A - -

Slot 8 UL: R R R R R R R R R R R R R R R R R R R - -
Problem 4

An analogic GSM system uses TDM-TDMA scheme with 10ms frame and 20 slots. The user voice coded using 16 kb/s is transmitted within the same slot. Assuming that the guard time is 0.1 ms, please calculate

1. How many bits the burst of one single slot should be designed and the speed in order to be transmitted.

2. What does it change when the user voice is transmitted within the same slot but only for 15 sequential frames while in the 16th frame there is a signalling slot. How much is signalling channel capacity?
Problem 4

The burst is calculated along the frame \( B = 16 \times 10 = 160 \text{bits} \)

The burst time is \( T_b = T_f - NT_g = 10\text{ms} - 20 \times 0,1\text{ms} = 0,4\text{ms} \)

The speed is calculated as follows

\[
V = \frac{B}{T_b} = \frac{160\text{bit}}{0,0004\text{s}} = 400\text{kb/s}
\]
Problem 4

The number of bits for 16 frames is $M = 16 \times 10 \times 16 = 2560$

This amount of bits has to be transmitted using 15 frames.

Therefore, the burst is $\frac{2560}{15} = 170.67$

The speed is $V = \frac{B}{T_b} = \frac{170,67}{0,0004s} = 426,67 \text{ kb/s}$

The signaling channel capacity is $v = \frac{B}{T_M} = \frac{170,67}{0,16s} = 1067 \text{ kb/s}$