IT.2307 – Mobile Networks
Homework 1: Planification and Dimensioning of Cellular Network

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Question 1 :

1) For the carrier frequency f_1= 800MHz, the communication range is higher than the other one because the wavelength is higher:

$$c = \lambda_1 . f_1$$

$$\lambda_1 = \frac{c}{f_1} = \frac{3.10^8 m.s^{-1}}{800.10^6 s^{-1}} \approx 0.375m$$

Indeed, for f_2 = 2.6GHz:

$$\lambda_2 = \frac{c}{f_2} = \frac{3.10^8 m.s^{-1}}{2600.10^6 s^{-1}} \approx 0.115m$$

So the operator should use the frequency 800MHz in a rural area and the frequency 2.6GHz in an urban area.

2) The penetration loss is higher for f_2 = 2.6GHz because λ_2 is smaller than λ_1 and therefore is littler compared to the depth of a wall.

Operators should use the high frequency 2.6GHz for a femtocell usage, so to keep the waves inside the building.

Question 2 :

G_{max} = 15.7dBi

$Loss_{cable}$ = 5dB

P_{max} = 30W

1) It means the antenna has a 15.7dB gain compared to an omnidirectional antenna which wouldn't have any gain for a specific direction.

2) We have 15°+15° = 30° between the maximal gain and the maximal gain−3dB. So the aperture of this antenna is **30°**.

3) People could use this antenna for a directional propagation like for an underground use or on a motorway.

4) EIRP(dBm) = P_{tmax}(dBm)+$Gain_{max}$(dB) $-$Loss(dB) = $10\log_{10}(30000)$+15.7dB$-$5dB $\approx$**55.47 dBm**

5) If we are at 270°+30° = 300° (or 270°$-$30° = 240°) then the gain is about $G_{max}-20$dB.

So the $EIRP_{300°}$(dBm) = P_{tmax}(dBm)+$Gain_{300°}$(dB) $-$Loss(dB) = $10\log_{10}(30000)$+15.7dB$-$20dB $-$5dB $\approx$35.47 dBm

The $EIRP_{300°}$(mW) $\approx 10^{3.547} \approx$3524mW = **3.524W**

<u>Question 3 :</u>

1) Multiplexing is when the different signals from different users can be received by an antenna and duplexing is when the transmission and the reception can be done by the same antenna.

2) The packet mode is when the packets are all coming at the same moment to give the most complete information once (it used for video transmissions), whereas the circuit mode is when the information is coming continuously, every fixed time, to have a permanent information (it is used for voice communication).

3) FDD (Frequency Division-Duplexing) is when we consider the downlink and uplink bands with different frequencies: transmission and reception cannot use the same frequency bands, and so transmission and reception can be done at the same moment.

TDD (Time Division-Duplexing) is when the transmission and reception are done with a certain delay between them: not done at the same moment.

So FDD is better for a symmetric communication.

Problem :

f_p =2.6GHz

$10\log_{10}(25)$ = 14.0dBm

1) For the uplink: the mobile device is the transmitter, the base station is the receiver.

$EIRP_{mob}$ (dBm) = P_{mob}(dBm) + $Gain_{mob\ ant}$ (dB) – $Loss_{mob\ ant}$ (dB) = 14+0+0 = 14dBm

$Power_{station}$(dBm) = $EIRP_{mob}$(dBm) + Gain(dB) – Loss(dB) – Pathloss(dB)

= 14 + 17 – 6 – 1 – 2 – Pathloss(dB) = 22 – Pathloss(dB) $\geq$ -110dBm

So Pathloss(dB) $\leq$ **132dB**

For the downlink: if we consider that the attenuation is the same for uplink and downlink communications, Downlink Pathloss = **132dB too**.

2) For 1 user:

$EIRP_{station}(dBm) = Power_{station\ 1\ user}(dBm) + Gain_{station}(dB) - Loss_{station}(dB)$

$= Power_{station\ 1\ user}(dBm) + 17 - 2$

$= Power_{station\ 1\ user}(dBm) + 15$

We have $Power_{mobile}(dBm) = EIRP_{station}(dBm) - Loss(dB) - Pathloss(dB) + Gain_{mobile}(dB)$

$= EIRP_{station}(dBm) - 6 - 1 - 132 + 0 = EIRP_{station}(dBm) - 139 \geq -103dBm$

So $EIRP_{station}(dBm) \geq 36dBm$

$EIRP_{station}(dBm) = 36\ dBm = Power_{station\ 1\ user}(dBm) + 15$ so:

$Power_{station\ 1\ user}(dBm) = 36\ dBm - 15 = 21\ dBm$

So $Power_{station\ 1\ user}(mW) = 10^{2.1} \approx 126$ mW and for the entire station:

$Power_{station} \approx 25 \times 126 \approx 3147$ mW so $Power_{station}$ (dBm) = $10\log_{10}(3147) \approx$ **35.0dBm**

3) $A_{dB} = 25.74 + 35\log_{10}(d) + 33.81\log_{10}(f_p)$

f_p = 2.6GHZ = 2600MHz

and A_{dB} = Pathloss = 132dB

So $25.74 + 35\log_{10}(d) + 33.81\log_{10}(2600) = 132$

and $35\log_{10}(d) = 132 - 25.74 - 33.81\log_{10}(2600) = 106.26 - 33.81\log_{10}(2600)$ so

$d = 10^{(106.26 - 33,81\log_{10}(2600))/35} \approx$ **0.546km**

Urban zone planification :

1) $\frac{C}{I} = \frac{1}{6}(\sqrt{3K})^{\gamma}$

We are looking for K. As $\frac{C}{I}$(dB) = 7dB, $\frac{C}{I} = 10^{0.7} \approx 5.01$

After computation, K will be the superior integer part of $10^{\frac{2log_{10}(6\frac{C}{I})}{\gamma}}.10^{-log_{10}(3)}$ so the superior integer part of 2.62 so 3.

K=3 so we have 3 cells in the pattern.

Then we have 3 pairs of bands: 1pair of bands / cell and so 25 radio resources / cell.

2) Each cell has 25 radio resources with a probability of blockage of 0.5%: when we read the table, we find a traffic of **15.00 Erlang** for each cell.

3) A user has 10 resources/second so 10 x 0.5ms = 5.10^{-3}s per second

So the ratio time used / 1 hour gives **5.10^{-3} Erlang** for a user.

We have 30/100 x 105.4 x 21000 = 664,020 users in the entire urban area.

So the total traffic is 664,020 x 5.10^{-3} = **3320.1 Erlang**.

4) Each cell can support 15 Erlang so if we take the superior integer part of the following number: $\frac{3320.1}{15} \approx 221.3$ we get **222 cells**.

5) $S_{cell} = \frac{105.4}{222} \approx$ **0.475 km²**

Or we have that $\frac{3\sqrt{3}}{2} d^2 = S_{cell}$ (with d being the distance between the centre of the cell and the side of the cell) so d = $\sqrt{\frac{2S_{cell}}{3\sqrt{3}}}$ and d $\approx$ **0.43 km**.

6) The radio planning is here the limiting factor because the dimensions found are quite realistic and do not seem to limit the communication range.