Wireless Communications and Mobile Networks Homework 2

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1 QUESTION 1

As we know, the co-channel interference ratio is defined as followed:

$$\frac{S}{I} = \frac{(D/R)^{\alpha}}{N_I} = \frac{\sqrt{3N}^{\alpha}}{N_I}$$

According to the question, the required signal-to-co-channel interference ratio is $18dB$. There fore:

$$10 \times \log_{10} \frac{S}{I} = 10 \times \log_{10} \frac{\sqrt{3N}^{\alpha}}{N_I} > 18dB$$

i)The path loss exponent is 3

(a)

$$10 \times \log_{10} \frac{\sqrt{3N}^{\alpha}}{N_I} > 18dB$$
$$\Rightarrow \quad N > 17.44$$

Therefore the minimum of the cluster size is 18.

(b)

The number of cell clusters in the service area is $\frac{100}{N} \approx 6$

(c)

The maximum number of users in service at any instant is:

$$500 \times 6 = 3000$$

ii)The path loss exponent is 4

(a)

The minimum of the cluster size is 6.

(b)

The number of cell clusters in the service area is $\frac{100}{N} \approx 17$

(c)

The maximum number of users in service at any instant is:

$$500 \times 17 = 8500$$

iii)The path loss exponent is 5

(a)

The minimum of the cluster size is 4.

(b)

The number of cell clusters in the service area is $\frac{100}{N} \approx 25$

(c)

The maximum number of users in service at any instant is:

$$500 \times 25 = 12500$$

iv)Discussion

As we can see above,the maximum number of users in service at any instant increase with the path loss exponent increasing, which means the performance of the frequency reuse is better with higher path loss exponent.

As for transmit power, referring to the equation:

$$P_r = P_0 \times d^{-\alpha}$$

We can see that, increasing the path loss exponent leads to lower power on the side of the receiver which means higher requirement for the receiver.

From the discussion, we can see that the path loss exponent leads to a trade off between the frequency reuse and the transmit power.

2 QUESTION 2

(a)

The frequency bands are 825 to 845 MHz for mobile unit transmission and

870 to 890 MHz for base station transmission. A duplex circuit consists of one 30-kHz channel in each direction,therefore:

$$K = \frac{20 \times 10^6}{30 \times 10^3} \approx 667$$

$$C = M \times K = 16 \times 667 = 10672$$

(b)

When the reuse factor N=4,

$$J = \frac{K}{N} == \frac{667}{4} \approx 167$$

When the reuse factor N=7,

$$J = \frac{K}{N} == \frac{667}{7} \approx 96$$

When the reuse factor N=12,

$$J = \frac{K}{N} == \frac{667}{12} \approx 56$$

When the reuse factor N=19,

$$J = \frac{K}{N} == \frac{667}{19} \approx 36$$

(c)

The area covered the different size of voice channel.

(d)

$$C = \frac{100}{N} \times J$$

When N=4,

$$C = \frac{100}{4} \times 167 = 4175$$

When N=7,

$$C = \frac{100}{7} \times 96 \approx 1372$$

When N=12,

$$C = \frac{100}{12} \times 56 = 467$$

When N=19,

$$C = \frac{100}{19} \times 36 = 190$$

3 QUESTION 3

Can't find the specific figure.

4 QUESTION 4

(a)

i=3,j=2.

(b)

i=2,j=3.

(c)

$$\begin{aligned} & \frac{D}{\sqrt{3}R} = \sqrt{N} \\ \Rightarrow \quad & D = \sqrt{57} \approx 7.55R \end{aligned}$$

(d)

$$\begin{aligned} \frac{S}{I} &= \frac{R^{-\alpha}}{2(D-R)^{-\alpha} + 2D^{-k} + 2(D+R)^{-k}} \\ &= \frac{1}{2(\sqrt{57}-1)^{-\alpha} + 2\sqrt{57}^{-k} + 2(\sqrt{57}+1)^{-k}} \end{aligned}$$

5 QUESTION 5

Imaging there are four cell A,B,C and D,B send RTS to A and C send RTS to C, and then A send CTS back to B which may make C confusing that D has already sent back CTS.

6 QUESTION 6

(a)

Referring to

$$f_r = f_c + f_d$$
$$f_d = \frac{f}{c} \times v \times cos\theta$$

Therefore the range of the frequency of received signals is from $1G - 18.52Hz$ to $1G - 74.07Hz$.

(b)

The Doppler effect is the change in frequency or wavelength of a wave (or other periodic event) for an observer moving relative to its source.

The difference in Doppler effect between different signal components contributing to a signal fading channel tap.

(c)

i)

$1G + 46.2Hz$

ii)

$1G - 46.2Hz$

iii)

$1G + 23.1Hz$

(d)

The terms slow and fast fading refer to the rate at which the magnitude and phase change imposed by the channel on the signal changes. The coherence time is a measure of the minimum time required for the magnitude change or phase change of the channel to become uncorrelated from its previous value.

Slow fading can be caused by events such as shadowing, where a large obstruction such as a hill or large building obscures the main signal path between the transmitter and the receiver. The received power change caused by shadowing is often modelled using a log-normal distribution with a standard deviation according to the log-distance path loss model.

Fast fading occurs when the coherence time of the channel is small relative to the delay requirement of the application. In this case, the amplitude and phase change imposed by the channel varies considerably over the period of use.

7 QUESTION 7

A Rayleigh distribution is often observed when the overall magnitude of a vector is related to its directional components.
The Rayleigh distribution's pdf is

$$f_{Ray}(r) = \frac{r}{\sigma^2} exp(-\frac{r^2}{2\ \sigma^2}), r >= 0$$

The Rican distribution is a generalization of the Rayleigh distribution. It is the probability distribution of the magnitude of a circular bivariate normal random variable with potentially non-zero mean.
Yet Rican distribution's pdf is

$$f_{Rican}(r) = \frac{r}{\sigma^2} exp(-\frac{r^2 + \alpha^2}{2\ \sigma^2}) I_0(\frac{\alpha r}{\sigma^2}), \alpha >= 0, r >= 0$$

where $I_0(x)$ is the zero-order modified Bessel function of the first kind. The pdf is the first difference between two distribution.

8 QUESTION 8

(a)

An analog cellular system has total of 33 MHz of bandwidth and uses two 25-kHz simplex (one-way) channels to provide full duplex voice and control channels. Therefore:

$$K = \frac{33 \times 10^6}{2 \times 25 \times 10^3} \approx 660$$

And the number of channels available per cell is:

$$J = K/N$$

where N is the reuse factor.

i)

$$J = K/N = 660/4 = 165$$

ii)

$$J = K/N = 660/7 \approx 94$$

iii)

$$J = K/N = 660/12 = 55$$

(b)
The lowest $1MHz$ channel should be the control channel for it can spread farther.

9 QUESTION 9

According to the textbook, the co-channel interference ration in the worst case for the forward channel occurs when the mobile unit located at the edge of the cell. And the interference ration is defined as followed:

$$\frac{S}{I} = \frac{R^{-\alpha}}{2(D-R)^{-\alpha} + 2D^{-\alpha} + 2(D+R)^{-\alpha}}$$

where α is the path loss exponent.
In the free-space model, the path loss exponent is supposed to be 2, therefore the interference ration is:

$$\frac{S}{I} = \frac{1}{2(\sqrt{19}-1)^{-2} + 2\sqrt{19}^{-2} + 2(\sqrt{19}+1)^{-2}}$$

In the two-way ratio model, the path loss exponent is 4, and then the interference ration should be:

$$\frac{S}{I} = \frac{1}{2(\sqrt{19}-1)^{-4} + 2\sqrt{19}^{-4} + 2(\sqrt{19}+1)^{-4}}$$