KFUPM - COMPUTER ENGINEERING DEPARTMENT

COE-543

Mobile and Wireless Networks

Instructor:

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Quiz No. 3

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1) (10 points) Assume that it is desired to deploy analog FM AMPS system with half band of 15 kHz rather than the existing 30 kHz. Also assume that in analog FM, the signal-to-interference requirement is inversely proportional to the square of the bandwidth (4 times increase in SIR for dividing the band into two).

a) What is the required SIR in dB for the 15 MHz channel if the required SIR for the 30 kHz systems is 18 dB.

18dB = $10^{18/10}$ in real = 63.1

63.1 * 4 = 252.4 ➔ In db: 10log 252.4 = 24dB

b) Determine the frequency reuse factor *N* needed for the implementation of the 15 kHz per user analog cellular system.

$$N = \frac{1}{3} \cdot [6 \cdot SIR]^{\frac{2}{\alpha}}$$

$$N = \frac{1}{3} \cdot [6 \cdot 252.4]^{\frac{2}{4}} = \frac{1}{3} \cdot [1514.4]^{\frac{1}{2}}$$

N = 38.9/3 = 12.96 = 13

c) If a service provider had a 12.5 MHz band in each direction (up-link and down-link) and it would install 30 antenna sites to provide its service, what would be the maximum number of simultaneous users (i.e. capacity) that the system could support in all cells. Neglect the channels that are used for control signaling.

No. of channels (Users) = 12.5 MHz / 15 KHz = $(12.5 * 10^6) / (15 * 10^3)$ = 833.3 = 833

No. of users per cell = 833 / 13 = 64

The maximum number of users that are used in the system that support 30 antennas
= 64 * 30 = 1920 user.

d) If we use the same antenna sites but for a 30 kHz per channel system with *N* = 7 (instead of the 15 kHz system) what would be the capacity of the new system.
Assume path loss exponent equal to 4.

No. of channels (Users) = 12.5 MHz / 30 KHz = $(12.5 * 10^6) / (30 * 10^3)$ = 416.6 = 416

No. of users per cell = 416 / 7 = 59.42 = 59

The maximum number of users that are used in the system that support 30 antennas
= 59 * 30 = 1770 user.

2) (20 points) Assume that STC had an initial deployment of GSM in the Eastern province with a frequency reuse pattern of N = 12. Due to increase in the demand for cellular services, STC engineers are to expand the system capacity using the reuse partitioning approach.

a) Assuming the new overlay network will use N = 7, compute the number of channels (belonging to the underlay and overlay networks) per cell. What is the capacity increase relative to the initial deployment?

The next figure shows the system for cluster size of 12.

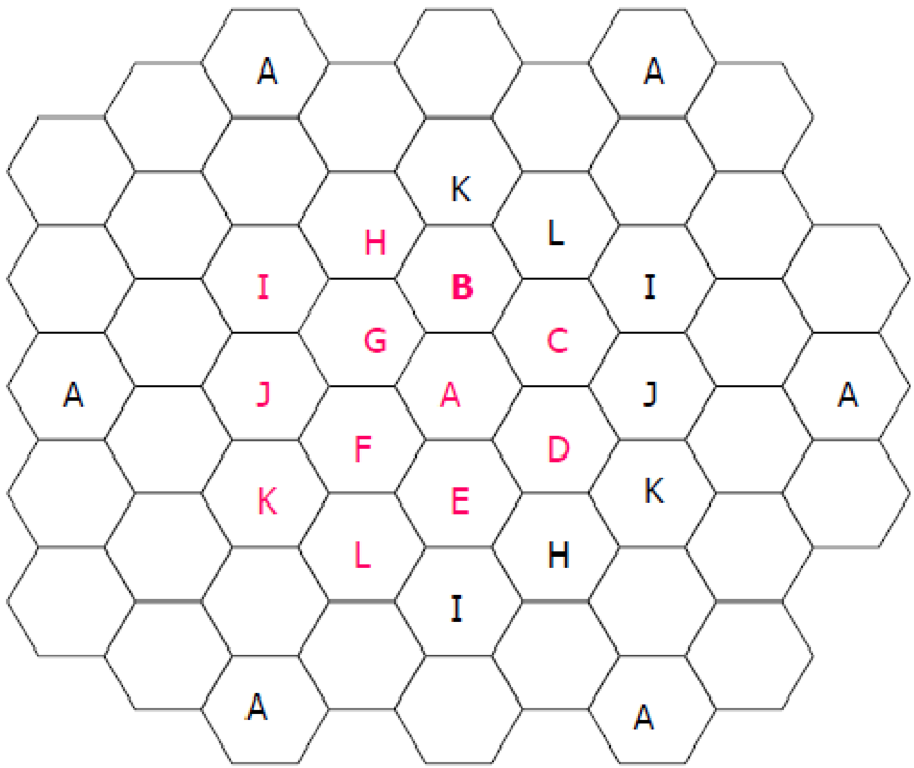

Figure 1: shows the mobile system with cluster size of 12.

$$\frac{D1}{R1} = \sqrt{3N} = \sqrt{3 * 12} = 6 = \frac{D2}{R2}$$

For N = 7, we can find the relation by plotting the cluster of 7 for the graph of cluster of 12. We should add the overlay for N = 7 over that of N = 12. The graph for this will be at the end of the solution.

Now, the next figure will show the clusters of size 7 which from it we could find the relation between D2 and R1. The radius for the cluster will be R1. The distance between the centers of nodes that numbered of 1 is D2.

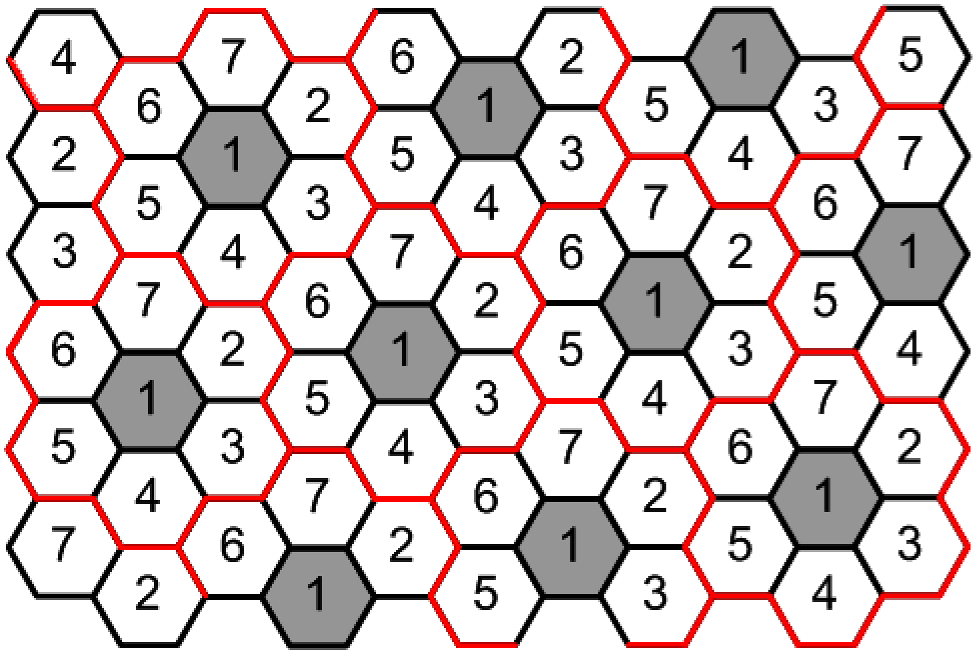

Figure 2: shows the mobile system with cluster size of 7.

From geometry, we can find that the difference in the x-access between the centers of nodes that numbered with one equal 4.5R1. The difference in the y-access is H which equal$\frac{\sqrt{3}}{2}$R1.

$$D2 = \sqrt{\left(4.5^2 + \left(\frac{\sqrt{3}}{2}\right)^2\right) \cdot R1^2} = \sqrt{(20.25 + 0.75) \cdot R1^2}$$

$D2 = 4.58R1$

$$6 = \frac{4.58R1}{R2}$$

$R2 = 0.763R1$

Distributing the total channels, N_c = 124, according to area, then the L channels per cell site is given by

$N_c = 124 = 12*(1-0.763^2)*L + 7*0.763^{2*}L$

124 = 12*0.418*L + 7*0.582*L

124 = 5.016*L + 4.074*L

124 = 9.09*L

L = 13.64 = 14

The overlay cell users = 0.763^2 * L = 0.582 * 14 = 8.15 = 8 users.

The underlay cell users = $(1 – 0.763^2)$* L = 0.418 * 14 = 5.85 = 6 users.

Original GSM provide $\frac{124}{12}$ = 10.3 = 10 users per cell site.

New capacity = $\frac{14}{10} = 140\%$

b) Assume that due to further increase in demand, STC plans to increase the capacity further by deploying another overlay network using *N* = 3 on top of the previous two layers (overlay with *N* = 7, and underlay with *N* = 12). Estimate now the new number of channels per cell and compute the capacity increase relative to the initial deployment?
Assume total number of channels equal to 124 for GSM network.

The same as for N = 7. But now I will add another overlay cell of cluster 3 but over that of cluster 7 which is over cluster 12.

For the relation distance between same nodes number of cluster N = 3, I will use the cluster of N=3 but with radius of the original one of N=12. The next image will shows that for N = 3. The last image will show the system with the three layers.

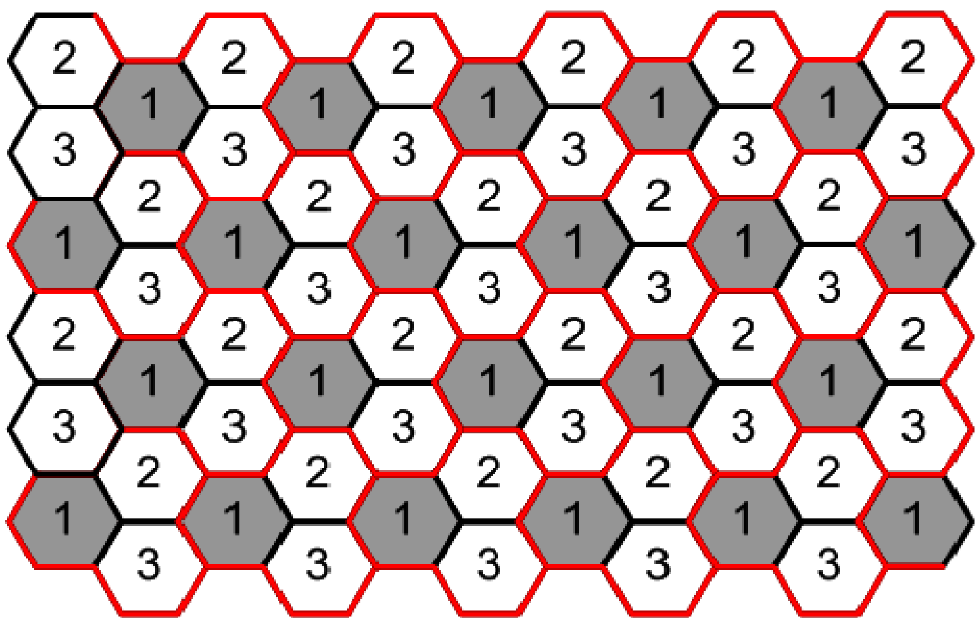

Figure 3: shows the mobile system with cluster size of 3.

From geometry:

D3 = 3R1

$$\frac{D1}{R1} = 6 = \frac{D3}{R3} = \frac{3R1}{R3}$$

R3 = $\frac{3}{6}R1 = \frac{1}{2}R1$

R3 = 0.5R1

Distributing the total channels, N_c = 124, according to area, then the L channels per cell site is given by

$124 = 12*(1-0.763^2)*L + 7*(0.763^2 - 0.5^2)*L + 3*0.5^2*L$

124 = 5.016*L + 2.33*L + 0.75*L

124 = 8.096*L

L = 15.3 = 15

The underlay cell users = $(1-0.763^2)*L$ = 0.418*15 = 6.27 = 6 users.

The overlay of N=7 cell users = $(0.763^2 – 0.5^2)*L$ = 0.332*15 = 4.98 = 5 users.

The overlay of N=3 cell users = 0.5^2*L = 0.25*15 = 3.75 = 4 users.

New capacity = $\frac{15}{10} = 150\%$

The next pages will show the system starting from the base to reach the one with the two overlays.

Now I will show the graphs one by one from the base system to the one with two overlays.

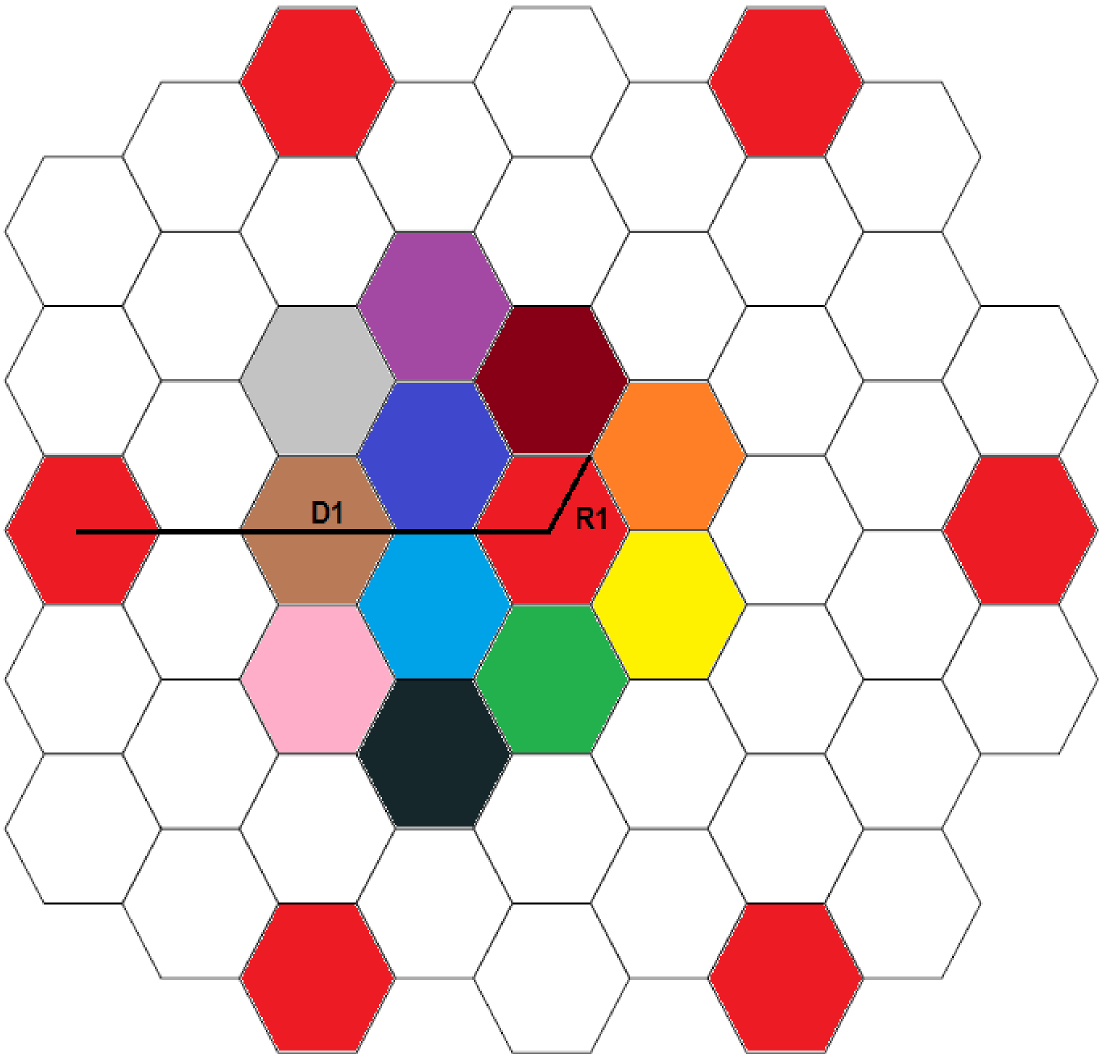

Figure 4: shows the graph for system with N=12.

We can notice that D1/R1 = 6.

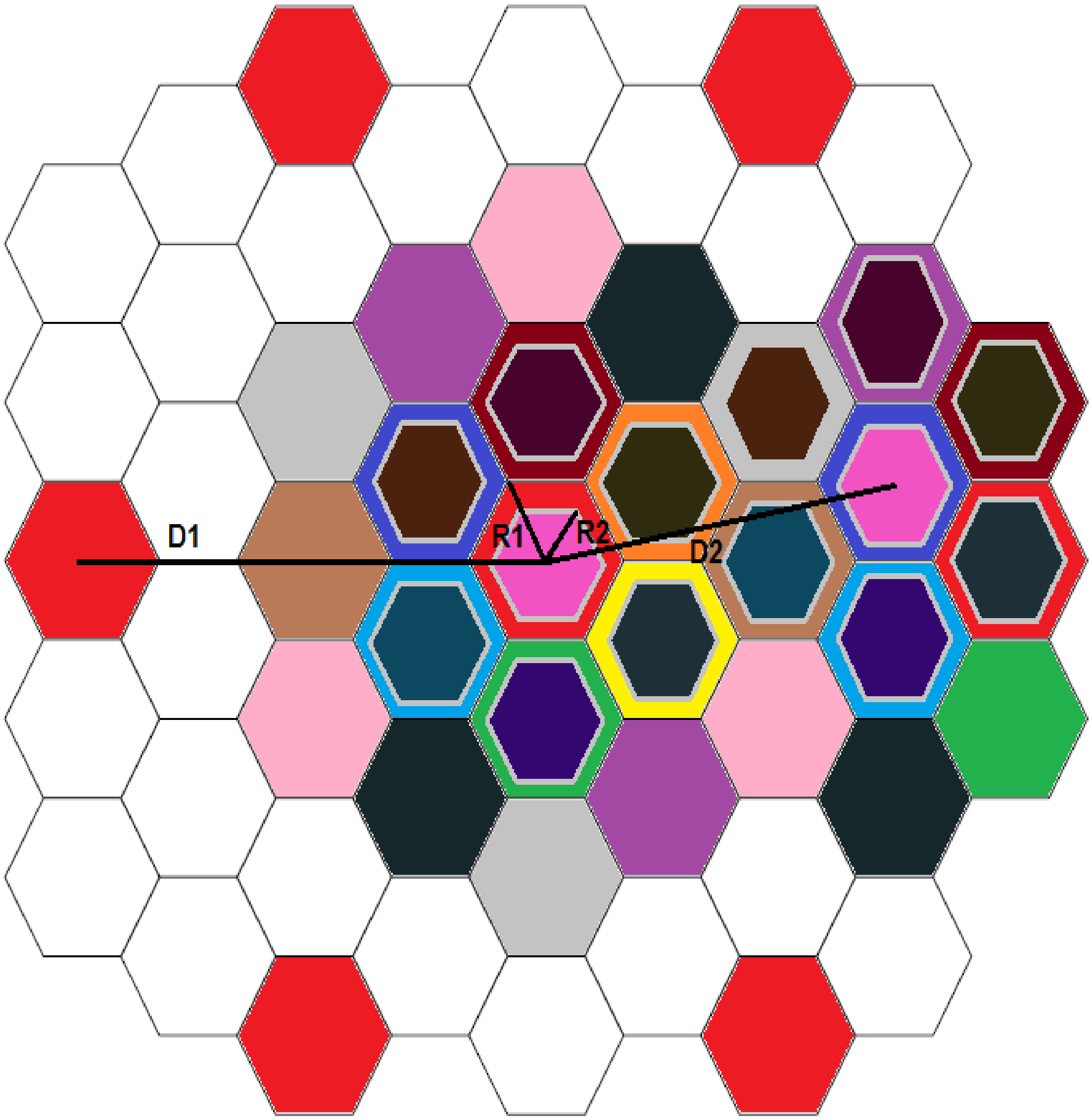

Figure 5: shows the graph for system with N=12 and overlay of N=7.

We can notice the difference between distances D1 & D2. Also the difference between R1 & R2. From this graph we find the relation between D2 & R1.

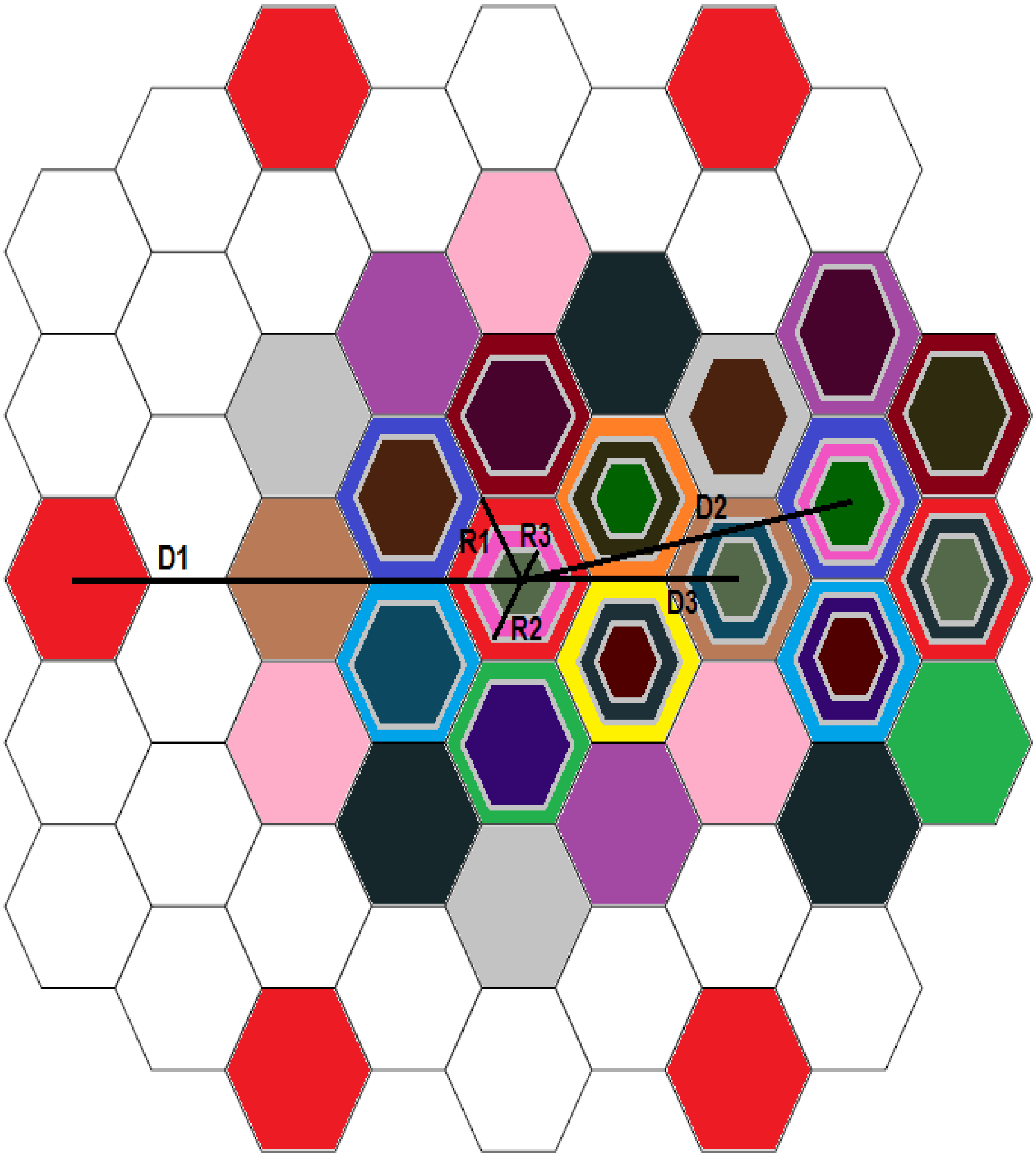

Figure 6: shows the graph for system with N=12 and overlay one of N=7 with another overlay of N=3.

From this graph we can find the relations between distances and radiuses. Also we could the relation between D3 & R1 which is D3 = 3R1.

The End