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3. (a) FDD is a common duplexing scheme used in cellular systems. Describe what is a FDD scheme. For a FDMA FDD cellular system, what is the typical relationship between the number of FDMA channels and the number of trunk channels?

Answer 3 (a) FDD is the frequency division duplex. Uplink and downlink transmission happens in different frequency band.

For FDMA FDD, the number of trunk channels is half of the number of the FDMA channels.

(b) A FDMA FDD cellular system has a system bandwidth of 6 MHz and each of its FDMA channels has a bandwidth of 50 kHz. If the system has a cluster size of 4, what is the number of trunk channels in each cell?

Answer: (b) $B_w = 6\,MHz$ $B_s = 50\,kHz$

Number of the total FDMA channels $n = \frac{B_w}{B_s} = \frac{6\times10^6}{50\times10^3} = 120$

Number of FDMA channels in a cell : $n_{cell} = \frac{n}{N_c} = \frac{120}{4} = 30$

Number of trunk channels in a cell : $n_t = \frac{n_{cell}}{2} = 15$

(c) For a blocking probability of 1% and considering the "blocked calls cleared model", what is the number of subscribers that can be supported in a cell by the same system described above if the average traffic flow needed by each subscriber is 0.1 Er? If the system covers an area of two million residents with 1000 cells, what is the market penetration rate? Assuming that every cell is of the same size of 3 km^2 approximately, what is the average spectral efficiency of the system in Er/MHz/km^2?

Answer: (c) GoS: P_b: 1% Blocked call cleared model, so look up the Erlang B Table

The supported offered traffic in a cell is $A = 8.108$ Erlang

The number of subscribers in a cell should be $n_s = \frac{A}{A_u} \approx 81$

If the system has 1000 cells, then the total number of subscribers of 81000

The penetration rate is $R = \frac{81000}{2\times10^6} \approx 4.05\%$

The spectrum efficiency is $\gamma_m = \frac{8.108\times4}{6\times3\times4} \approx 0.45$ Erlang/MHz/km^2

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3. (d) It is found that the above cellular system experience too much co-channel interference. As a result, 120° sectorized antennas were incorporated into all base stations of the system. In addition, the system operator plans to double the penetration rate determined in part (c) and expand the system capacity by adopting the cell splitting technique. Approximately, how much smaller should the 'radius" of the micro cell be compared to that of the original cell, assuming that each cell has a hexagonal geometry and the 'radius' is the distance between the center and the vertex of the cell? Explain your answer.

Answer: (d) Double the penetration rate $R_p = 8.1\%$

The user density is $d = \frac{2\times10^6}{1000\times3} \approx 666.67$ user/km²

Assume the Radius of a cell is R

The size of a cell $S = R \cdot \frac{\sqrt{3}}{2}R \cdot \frac{1}{2} \times 6 = \frac{3\sqrt{3}}{2}R^2$

The size of a sector in the cell is $S_s = \frac{\sqrt{3}}{2}R^2$

The number of subscribers in a sector is $n_s = S_s \cdot d \cdot R_p = \frac{\sqrt{3}}{2}R^2 \times 666.67 \times 8.1\%$

The number of channels in a sector: $\frac{15}{3} = 5$; GoS: $P_d = 1\%$

Look up the Erlang B table, and find the offered traffic is 1.361 Erlang.

$\frac{A}{A_u} = n_s \quad \frac{1.361}{0.1} = \frac{\sqrt{3}}{2}R^2 \times 666.67 \times 8.1\%$

$R \approx 0.54$ km

The radius should be 0.54 km.