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3. (a) A heavily populated small island has a user density of 720 users per km^2 for the service area. The operator A decides to select a cellular system that has a cluster size $N_c = 7$ and a total of 399 duplex traffic channels. The system uses a fixed channel assignment, blocked calls cleared scheme and omni-directional antennas at the base station (BS). During the busy hour, on the average, a user generates 0.9 call with a holding time of 90 seconds. The expected Grade of Service (GOS) is given by 1% blocking probability. The service area will be covered by hexagonal cells with radius R. Note: The area of each hexagonal cell is $A_{ce} = \frac{3\sqrt{3}}{2} R^2$. State and justify any necessary assumptions.

(i) Determine the number of channels per cluster and the offered traffic supported by the GOS.

Answer (i) There are 399 channels per cluster.

There are $399/7 = 57$ channels per cell

GoS: $P_b = 1\%$

According to the blocked call clear scheme, we should look up the Erlang B Table

Offered traffic should be $A = 44.2$ Erlang

The offered traffic in a cell is 44.2 Erlang supported by the GoS.

The offered traffic in a cluster is 309.4 Erlang supported by the GoS.

(ii) Determine the number of users m and the offered traffic generated by users in each cell.

Answer: (ii) $m = 720 \times A_{ce} = 720 \times \frac{3\sqrt{3}}{2} R^2 = 1080\sqrt{3} R^2$

$\mu = 0.9$ call/h holding time: $h = 90s = \frac{1}{40} h$

$A_u = \mu \times h = 0.9 \times 90 = 0.01$ Erlang.

$A = m \cdot A_u = 1080\sqrt{3} R^2 \times 0.01 = \frac{1080\sqrt{3}}{100} R^2$ Erlang.

The number of users in a cell is $m = 1080\sqrt{3} R^2$

The offered traffic generated by users in a cell is $\frac{1080\sqrt{3}}{10} R^2$ Erlang.

(iii) Determine the cell radius R, when the offered traffic generated by users is equal to the offered traffic supported for the given GOS for each cell.

Answer (iii) Let $A_{GoS} = A_{user}$

$\frac{1080\sqrt{3}}{100} R^2 = 44.2$

$\therefore R \approx 1.54$ km

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3 (a) (iv) Determine the trunking gain T_g of the system.

Answer: (iv) Supported user number $n = \frac{A_{GoS}}{A_u} = \frac{44.2}{0.01} = 4420$ in a cell

$T_g = \frac{n}{n_{ch}} = \frac{4420}{57} \approx 77.54$

The system trunking gain is 77.54.

(v) Suppose the operator A decides to improve the hexagonal cellular design further where one uses the 120-degree sector being deployed in each cell for the BS. For this new design, calculate the new value of *R* and T_g. State your observation and comment on the changes to the results from the operator's perspective.

Answer: (v) The number of channels in each sector $57/3 = 19$

GoS: $P_b = 1\%$

Offered traffic supported by GoS is 11.2 Erlang in a sector according to Erlang B Table.

$A_{GoS} = 11.2 \times 3 = 33.6$ Erlang

Let $A_{GoS} = A_{user}$

$\frac{1080\sqrt{3}}{100} R^2 = 33.6$

$\therefore R \approx 1.34$ km

The user number in a cell is $\frac{A_{GoS}}{A_u} = 3360$

Trunking gain $T_g = \frac{3360}{57} \approx 58.95$

After the sectoring, trunking gain and radius of a cell all decreases.

But with the effect of directional antennas, the SIR in the system will also decrease, which means we can use smaller reuse distance to increase the system capacity.

3. (b) Multiple access schemes are important features in mobile cellular systems as they allow many users to share the limited spectrum simultaneously. There are three basic multiple access schemes used in the 1G-3G mobile cellular systems. Briefly describe each of the multiple access schemes and give an example of an existing mobile cellular system for each scheme.

Answer: FDMA: Frequency Division Multiple Access

Description: Divide the frequency band into small bands, each small band serves as a sub channel, which allows a user's signal to access and transmit. Example: AMPS

TDMA: Time Division Multiple Access

Description: Divide the time domain into different slots, each slot allocates to a user. Narrow band TDMA = FDMA + TDMA

Example: GSM

CDMA: Code Division Multiple Access Description: Use different orthogonal code to transmit different users' signals.

Example: CDMA2000.