**Q5. (12 Marks)** Consider a **GSM** system with spectrum allocation of **890-915MHz UL** and **935-960MHz DL**, with **channel spacing** of **200 kHz** and a reserved **guard band** of **100 kHz** at the **beginning** and the **end for each** of the **UL** and **DL** spectrum and **8 voice channels per digital channel**.

A. How many **voice channels** in this system?
B. Calculate the **cluster size N** for this system if the required signal to interference ratio **S/I** is **14 dB** and the **path loss exponent n= 4**? (Assume that there are **6 co-channels cells** in the first tier, and all of them are **at the same distance from the mobile**)
C. Calculate the **Co-channel distance**?
D. What is the **number of voice channels per cell** in GSM under the given **S/I condition**?
E. **How many** omnidirectional **base stations** having **2 km** coverage **radius** are required to cover an area of **312 km$^2$**? Use the **hexagonal** cell shape?
F. What is the **maximum number** of **simultaneous users** in the network?

**Solution:**

A. *890-915 MHz for uplink → 25 MHz bandwidth*
*935-960 MHz for downlink → 25 MHz bandwidth*
*We have 25 000 KHz/200 kHz = 125 channels, one of which is reserved for guard band and 124 channels remain for users. On each channel 8 voice channels are carried by using 8 time-multiplexing.*
*Total number of voice channels=124 x 8 = 992.*

B. $S/I = Q_n / 6 = 1/6\ (3N)^{n/2}$ „
*Cluster size for a given S/I is:* $N = 1/3\ (6\ S/I)^{2/n}$
*14 dB* $\Leftrightarrow S/I=25.11$
$N = 1/3\ (6 \times 25.11)^{2/4} = 4.09 \rightarrow N=7$

C. *Co-channel distance* $D = R\sqrt{(3N)} = R\sqrt{(3x7)}$ *for N=7*

D. *[124 RF channels / 7 Cells/cluster] = 18 channels per cell for 5 cells and 17 channels per cell for 2 cells.*
*[124 RF channels / 7 Cells/cluster] x 8 voice channel = 136 voice channels per cell for 2 cells and 144 channels per cell for 5 cells.*

E. *Cell area is = 2.6 R2 = 2.6 x 22 = 10.4 km2*
*Number of required base stations = 312/10.4 = 30 base stations*

F. *Maximum number of simultaneous users (channels) = 136 user/cell x 30 cells = 4080 channels*

**Q4. (8 Marks)** A **cellular system** with **cluster size** of 7, probability of **blocking** of **1%**, average **call duration** of **2 minutes**, each user has a **call rate** of **1 call per hour**, and omnidirectional antenna cells with **60 traffic channels each**. Assuming that **blocked call cleared** system is used, **Find** the following:

a) **Maximum number of users** that can be supported per cell.
b) **Co-channel reuse ratio** and **frequency reuse distance**, if the **cell radius** is **1.3 km**.
c) **Traffic capacity loss** due to trunking the traffic channels when going from **omnidirectional** to **60°** sectored antennas.
d) What is **co-channel interference**? And how it can be **reduced**?

**Solution:**

a) **N = 7, GOS = 1%, H = 2 minutes, λ = 1 call/hour, #Ch = 60, Erlang B (blocked-call cleared system) from Erlang B table, A = 46.95 erlangs**
**Au = H . λ = 2 * 1/60 = 1/30 erlangs**
**# U_cell = A / Au = 46.95 / (1/30) = 1408 users per cell**
**# U_culster =1408 * 7 = 9856 users per cluster**

b) **Co-channel reuse ratio: Q = D/R = $\sqrt{3N} = \sqrt{3 * 7} = 4.58$**
**Frequency reuse distance: D = R * Q = 1.3 km * 4.58 = 5.96 km**

c) **When employing 60° sectoring, there are only 10 channels per antenna sector 60/6, So**
**GOS = 1%, H = 2 minutes, λ = 1 call/hour, #Ch = 60/6, from Erlang B table, A = 4.461erlangs**
**Au = H . λ = 2 * 1/60 = 1/30 erlangs**
**# U_sector = A / Au = 4.461/ (1/30) = 133 users per sector**
**# U_cell = # U_sector * 6 = 133 * 6 =798 users per cell**
**# U_culster =798 * 7 = 5586 users per cluster**
**Traffic capacity loss when compared to the unsectored case = 1 – 798/1408 = 0.433 = 43.3%**
**Thus, sectoring decreases the trunking efficiency while improving the S/I for each user in the system.**

d) **The interference between signals from co-channel cells (cells that use the same set of frequencies) is called co-channel interference.**
**Co-channel interference can be reduced by using:**
- **directional antennas (Cell sectoring)**
- **Adaptive Power Control**

كلية التقنية الالكترونية
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قسم الاتصالات. أسئلة الامتحان النهائي لمادة: أجهزة اتصالات II.
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اسم الطالب: ..... ، رقم القيد: .....

(يسمح للطالب بإدخال ورقة قوانين جهة واحدة A4 وجداول Erlang مع ضرورة كتابة الاسم عليها وتسليمها مع كراسة الاجابة)

**Q1. (6 Marks)** A satellite at a **distance** of **40000 km** from an earth station radiates a **power** of **3 W** from an antenna with a **gain** of **15 dB** in the direction of the earth station. If the receiving antenna has an **effective area** of **10 m²** and the receiver has a **noise temperature** of **500 K**. Calculate the **C/No** ratio in **dB** at the receiver?

**Solution:**

**Flux density**: $F = EIRP - 10\log(4*pi*d^2) = 10\log(3) + 15 - 10\log(4*pi*(40000e3)^2) = -143.2621$ dBW/m²

**Power received:** $Pr = EIRP / (4*pi*d^2) * A_{eff} = F + 10\log(A_{eff}) = -143.26 + 10\log(10) = -133.2621$ dBW

**Noise power density:** $No = kT = 10\log(1.38\times10^{-23} \times 500) = -201.6115$ dBW

**C/No = Pr – No = -133.2621 + 201.6115 = 68.3494 dB.**

**Q2. (6 Marks)** An **earth station antenna** is located at **89°W longitude** and **35°N latitude**. It is intended to transmit and receive signals to a satellite in **geostationary** orbit at **82°W longitude** and height of 38000 km. Calculate the **intermediate angle** from earth station?

**Solution:**

**Intermediate angle (α) = $\tan^{-1}[\tan|(ls - le)| / \sin(Le)] = \tan^{-1}[\tan|(82 - 89)| / \sin(35)] = 12.0828°$.**

**Q3. (6 Marks) Derive** the **co-channel reuse ratio** for a **hexagonal geometry**, where $N = i^2 + ij + j^2$ is used to find the nearest co-channel neighbors for a particular cell?

**Solution:**

have

$D = [i(2R')]^2 + [j(2R')]^2 - 2i(2R')\cdot j(2R')\cdot\cos 120°$

When $R' = \frac{\sqrt{3}}{2}R$, therefore

$D = \sqrt{3i^2R^2 + 3j^2R^2 + ij\cdot 3R^2}$

$= \sqrt{3(i^2+ij+j^2)}\cdot R$

$= \sqrt{3N}\cdot R$

Hence, $G = \frac{D}{R} = \sqrt{3N}$