Class: 4th

MOBILE COMMUNICATIONS

Tetorial 2

Chapter Two

The Cellular Concept-System Design 1

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Q1/ What are the main components of GSM and NSS

GSM components

- MS (mobile station)
- BS (base station)
- MSC (mobile switching center)
- LR (location register
- NSS Components
- Mobile Services Switching Center (MSC)
- Databases (important: scalability, high capacity, low delay)

i. Home Location Register (HLR) : central master database containing user data

ii. Visitor Location Register (VLR) : local database for a subset of user data

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Q2a:What is the (frequency reuse)? And how does it relates to (N) ?

Solution:

"Frequency reuse "is the design process of selecting and allocating channel groups for all of the cellular base stations within a system.

Small N:

- More cluster are required to cover the service area
- More capacity
- Higher probability of co-channel interference

Large N:

- Less cluster are required to cover the service area
- Less capacity
- Less probability of co-channel interference

Q2b: What are the effects of decreasing the cell size ?

Solution:

1. Decreasing the cell size gives:

2. Increased user capacity

3. Increased number of handovers per call

4. Increased complexity in locating the subscriber

5. Lower power consumption in mobile terminal: so it gives longer talk time, safer operation

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Q3: What are the advantages of hexagon?

Solution:

1. No gaps or overlapping

2. The largest area compared with square and triangle.

3. Fewest number of cells can cover a geographic region,

4. Closely approximates a circular radiation pattern which would occur for an omnidirectional base station antenna and free space propagation.

5. A hexagonal pattern provides for equidistant antennas

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Q4 a: what are types channels in cellular system between the base station and the mobiles

Solution:

1. Forward Voice Channel (FVC): This channel is used for the voice transmission from the BS to the MS.

2. Reverse Voice Channel (RVC): This is used for the voice transmission

from the MS to the BS.

3. Forward Control Channel (FCC): The FCC is used for control signaling purpose from the BS to MS.

4. Reverse Control Channel (RCC): This is used for the call control purpose from the MS to the BS. Control channels are usually monitored by mobiles.

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Q4 b: What are the types of cells used in cellular system?

1. Macro-cells: coverage area is large (approximately 6 miles in diameter) used in remote areas . high power transmitter and receiver are used.

2. Micro-cells: coverage area is small(about0.5 miles diameter) .used in Urban zones. Low power transmitter and receiver are used to avoide interference with cells in another clusters

3. Pico-cells: is a small cellular system typically covering small cellular areas such as in building (offices,shopping malls,train station) .

4. Selective-cells: located at the entrance of tunnels, where coverage of 360 degree is not needed In this case, a selective cell with a coverage of 120 degree is used.

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Q5\ explain call is set up from source to the destination device

- Mobile device is connected to BTS (Antenna).
- BTS is connected to the Switching system called BSC.
- BSC is connected to the main switching system called MSC.

MSC contains its own VLR (VLR: is a temporary database which stores the information of the visitors under its coverage area. VLR stands for Visitor

Location register. When you roam in a different place VLR stores your user information.).

- MSC's are connected to GMSC which is connected to HLR. (HLR stands for Home location register, it is the main database where the documents or information of user is stored. all the documents that you give during purchase of a SIM card is stored in this HLR.
- VLR Takes your information from HLR when you Roam in other state or region.).
- HLR also provides authentication by AuC. AuC is connected with HLR. If you initiate a call HLR and AuC will see if you are a genuine Mobile user with valid IMEI number and Plan. And then the call is set up from source to the destination device.

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Q6: Assume a system of 32 cells with a cell radius of 1.6 km, a total of 32 cells, a total frequency bandwidth that supports 336 traffic channels, and a reuse factor of N = 7.

(a) If there are 32 total cells, what geographic area is covered, how many channels are there per cell, and what is the total number of concurrent calls that can be handled?

(b) Repeat for a cell radius of 0.8 km and 128 cells.

Solution:

(a)

The area of a hexagon of radius R is

$$Area_a = \frac{3\sqrt{3}}{2}R^2 = \frac{3\sqrt{3}}{2}(1.6)^2 = 6.65\,\text{km}^2$$

The total area covered is $6.65 \times 32 = 213$ km^2.

For $N = 7$, the number of channels per cell is $K/N = 336/7 = 48$,

Total number of concurrent calls that can be handled is

$$Capacity = 48 \times 32 = 1536 \text{ channels}$$

(b)

The area of a hexagon of radius R is

$$Area_b = \frac{3\sqrt{3}}{2} R^2 = \frac{3\sqrt{3}}{2} (0.8)^2 = 1.66 \text{km}^2$$

The area covered is $1.66 \times 128 = 213$ km^2.

The number of channels per cell is $K/N = 336/7 = 48$,

Total number of concurrent calls is

$$Capacity = 48 \times 128 = 6144 \text{ calls}$$

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Q7: Assume a system of 34 cells with a cell radius of 1.4 km, a total frequency bandwidth that supports 441 traffic channels, and a reuse factor of N = 7.

(a) what geographic area is covered, how many channels are there per cell, and what is the total number of concurrent calls that can be handled?

(b) Repeat for a cell radius of 0.9 km and 130 cells.

Solution:

(a)

The area of a hexagon of radius R is

Areaa = 2.598 R22.5981(1.4)2 = 5.092 km2

The total area covered is 5.092 × 34 = 173 km2.

For N = 7, the number of channels per cell is S/N = 441/7 = 63,

Total number of concurrent calls that can be handled is

Capacity = 63 × 34 = 2142 channels

(b)

The area of a hexagon of radius R is

Areaa = 2.5981 R2 = 2.5981(0.9)2 = 2.104 km2

The area covered is 2.104 × 130 = 273.5 km2.

The number of channels per cell is S/N = 441/7 = 63,

Total number of concurrent calls is

Capacity = 63 × 130 = 8190 calls

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Q8: Consider a cellular system in which total available voice channels to handle the traffic are 968. The area of each cell is 5 km2 and the total coverage area of the system is 2500 km2. Calculate:

(a) The system capacity if the cluster size N is 4

(b) The system capacity if the cluster size is 7.

• Does decreasing N increase the system capacity? Explain.

Solution :

The first solution

Total available channels k =968 , Cell area = 5 km2

Total coverage area = 2500 km2

a. N = 4

Area of a cluster = 4 × 5 = 20 km2

M = Number of clusters for covering total area = 2500/20 = 125

Number of channels per cell = K/N = 968/4 = 242

System capacity = 125 × 968 = 121000 channels

b. N = 7

Area of cluster = 7 × 5 = 35 km2

M= Number of clusters for covering total area = 2500/35 = 71.428 ~ 71

Number of channels per cell = 968/7 = 138.28 ~ 138

System capacity = 71 × 968 = 68728 channels

It is evident when we decrease the value of N from 7 to 4, we increase the system capacity from 68728 to 121000 channels. Thus, decreasing N increases the system capacity.

b. N=7

Number of channel per cell = K/N

=968/7 = 138ch/cell

Capacity= total number of cells×number of channel per cell

= 500 ×138= 69000

It is evident when we decrease the value of N from 7to 4, we increase the system capacity from 68000 to 121000 channels. Thus, decreasing N increases the system capacity.

Q9: Consider a cellular system in which total available voice channels to handle the traffic are 900.The area of each cell is 5 km2 and the total coverage area of the system is 2000 km2. Calculate:

(a) The system capacity if the cluster size *N* is 4

(b) The system capacity if the cluster size is 7.

Does decreasing *N* increase the system capacity?

Solution:

Total available channels =900 , Cell area = 5 km2

Total coverage area = 2000 km2

a. $N = 4$

Area of a cluster = 4 × 5 = 20 km2

M= Number of clusters for covering total area = 2000/20 = 100

Number of channels per cell = K/N = 900/4 = 225

System capacity = 100 × 900 = 90000 channels

b. $N = 7$

Area of cluster = 7 × 5 = 35 km2

M=Number of clusters for covering total area = 2000/35 = 57.1 ~ 57

Number of channels per cell = K/N = 900/7 = 128.57 ~ 129

System capacity = 57 × 900 = 51300 channels

It is evident when we decrease the value of *N* from 7 to 4, we increase the system capacity from 51,300 to 90,000 channels. Thus, decreasing *N* increases the system capacity.

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Q10: Define the following:

1. Call Blocking.

2. Call Termination.

3. Call Drop.

4. Frequency Reuse Process.

5. MSC

Answers:

1. **Call blocking:** the traffic channels assigned to the nearest BS are busy during the mobile-initiated call stage, after a certain number of failed tries, a busy tone is returned to the user.

2. **Call termination:** When one of the two users hangs up, the MTSO is informed and the traffic channels at the two BSs are released.

3. **Call drop:** the BS cannot maintain the minimum required signal strength for a certain period of time, because of interference or weak signal spots in certain areas.

4. **Frequency Reuse Process** is the design process of selecting and allocating channel groups for all of the cellular base stations within a system.

5. MSC: The center which is set up for coordinating the routing of calls, also called a **mobile switching center (MSC)**. **The main functions of the MSC are:**

1- Assigns the voice channel to each call.

2- Performs handoffs.

3- Monitors the call for billing information.

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Q11: Assume a system of 34 cells with a cell radius of 1.4 km, a total of 34 cells, a total frequency bandwidth that supports 350 traffic channels, and a reuse factor of $N = 7$.

(a) If there are 34 total cells, what geographic area is covered, how many channels are there per cell, and what is the total number of concurrent calls that can be handled?

(b) Repeat for a cell radius of 0.7 km and 130 cells.

Solution:

a. The area of a hexagon of radius R is

$Area=3\sqrt{3}2R2=3\sqrt{3}2(1.4)2=5\ km2$

The total area covered is 5 × 34 = 170 km2.

For N = 7, the number of channels per cell is K/N = 350/7 = 50,

Total number of concurrent calls that can be handled = *Capacity* = 50 × 34 = 1700 channels

b. The area of a hexagon of radius R is

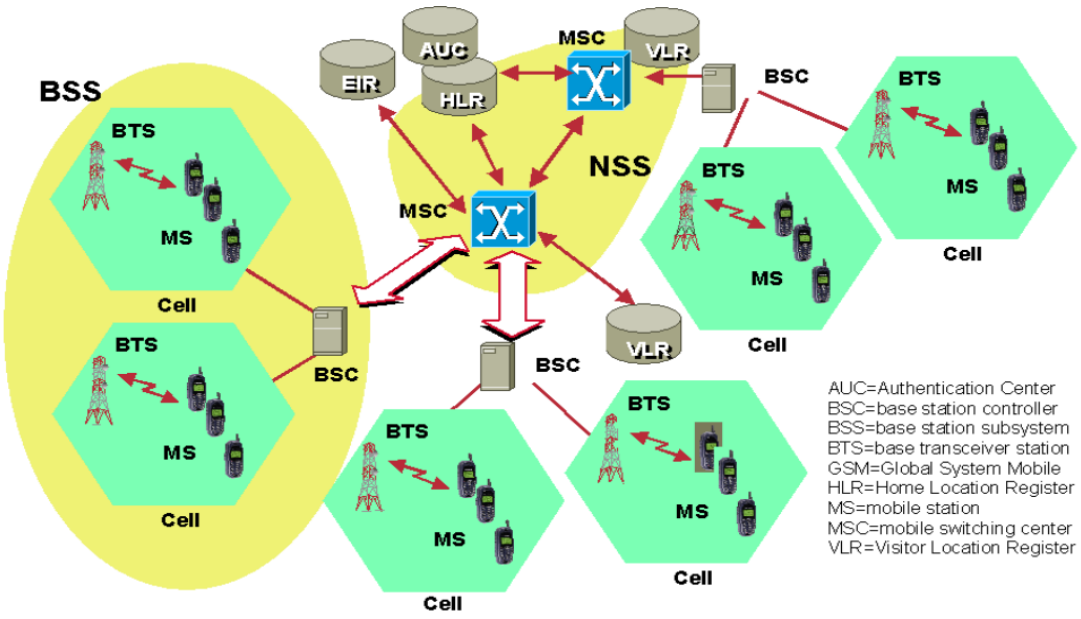
$Area=3\sqrt{3}2R2=3\sqrt{3}2(0.7)2=1.27\ km2$

The area covered is 1.27 × 130 = 165 km2.

The number of channels per cell is K/N = 350/7 = 50

Total number of concurrent calls that can be handled = *Capacity* = 50 × 130 = 6500 calls.

Q13: Draw the basic structure diagram of the Global System of Mobile (GSM) system?



Q14: Consider a cellular system in which total available voice channels to handle the traffic are 850. The area of each cell is 7 km2 and the total coverage area of the system is 1500 km2. Calculate:

(a) The system capacity if the cluster size N is 7

(b) The system capacity if the cluster size is 12.

Solution:

Total available channels = 850 Cell area = 7 km2

Total coverage area = 1500 km2

a. N=7

Area of cluster =7×7=49 $Km2$

M= Number of clusters for covering total area=150049=30.6≅30

system capacity=30×850=25500 channel.

b. N=12

Area of cluster =12×7=84 $Km2$

M= Number of clusters for covering total area=150084=17.8≅17

system capacity=17×850=14450 channel.

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Q15: Assume a system of 32 cells with a cell radius of 2 km, a total frequency bandwidth that supports 672 traffic channels, and a reuse factor of N = 7.

If there are 32 total cells, what geographic area is covered, how many channels are there per cell, and what is the total number of concurrent calls that can be handled?

Solution:

The area of a hexagon of radius R is $Area$=3√32R2=10.39 km2 The total area covered is=10.39 × 32 = 332.55 km2

For N = 7, the number of channels per cell is K/N = 672/7 = 96

Total number of concurrent calls = Capacity = 96 × 32 = 3072 channels.

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Q16: Assume a system of 44 cells with a cell radius of 2.1 km. A total frequency bandwidth that supports 540 traffic channels and a reuse factor of N=12.

(a) find the coverage geographic area, the no. of channels per cell and the total number of concurrent calls that can be handled

(b) repeat for a cell of radius 0.7 km and 200 cells

Solution:

a. R = 2.1km No. of cells = 44

The area of hexagon of radius

$area\ of\ the\ cell$=3√32R2=3√32(2.1)2=11.46 km2

The total coverage area = 11.46 x 44= 504.13 km2

The no. of channels per cell = K/N = 540/12 = 45

The total no. on concurrent calls $capacity$=45 x 44=1980 $channels$

b. R = 0.7 km No. of cells = 200

The area of hexagon $area\ of\ the\ cell$=3√32(0.7)2=1.27 km2

The covered area=1.27*200=254 km2

The no. of channels per cell=K/N=540/12=45ch/cell

The total no. of concurrent calls= Capacity =200 x 45 =9000 calls

Q17: consider a cellular system in which total available voice channels to handle traffic are 1000. The area of each cell is 5km2 and the total coverage area of the system is 2500 km2 calculate :

a. The system capacity if the cluster size N is 4

b. The system capacity if the cluster size N is 7

How many times would a cluster of size 4 have to be replicated to cover the entire cellular system? does decreasing N increases system capacity ?explain.

Solution

Total available channels =1000

Cell area=5 km2

Total coverage area =2500 km2

a. N=4

Area of cluster=4 x 5 =20 km2

Number of clusters for total coverage area =2500/20=125

Number of channels per cell=1000/4=250 ch/cell

System capacity =125 x 1000=125000 channels

b. N=7

Area of cluster =7x 5=35 km2

Number of clusters for covering total area =2500/35=71.43≅71

Number of channels per cell= K/N =1000/7=142.8≅143chs/cell

System capacity=71 x 1000=71000 channels

It is evident that when we decrease N from 7 to 4 we increase system capacity from 125000 to 71000 channels

Thus decreasing N increases system capacity