ACRONYMS

- PSTN : Public Switched Telephone Network
- BTS : Base Transceiur Station
- MSC : Mobile Switching Center
- HO : Hand-Off
- SIR : Signal to Interference Ratio

7.1 INTRODUCTION

To fulfil the requirement of day-by-day increasing number of mobile users, some techniques are required to utilize the available channel (set of frequencies or allowed frequency spectrum) more efficientlly so as to avoid, congestion. The techniques allow us to increase the system capacity of the existing systems. Therefore, frequency reuse concept came into evolution. But simultaneously this frequency reuse technology faces the challenge from interference between the communications of various radio signals. This chapter deals with frequency reuse strategy, interference, hand-off strategy, cell sectoring and various other technologies to improve cellular transmission and system capacity.

7.2 THE CELLULAR CONCEPT

The cellural systems are high capacity land-mobile system in which assigned radio spectrum is divided into discrete channels which are assigned in groups to geographic cells covering cellular geographic area. The discrete channels are capable of being reused in different cells through a process known as *frequency reuse*.

The cellular system is similar in functional design to the public switched telephone network (PSTN) or landline network. The exitance and control of the radio function of the cellular system is what differentiates cellular from landline telephone service.

7.3 THE CELL

A small geographic region that is served by a single base station for communication of traffic is known as a cell. A group of cells is known as a *cluster*. The main thing that should be kept under consideration during formation of a cell is its shape so that entire region could be covered up without any gap or overlap in between cells. Different shapes of the cell and their selection criteria is given in article 7.5.1.

7.4 MAIN COMPONENTS OF A CELLULAR TELEPHONE SYSTEM

There are five main components of a cellular telephone system. These are:

1. the mobile phone,
2. the cell base transceiver station (BTS) or base station,
3. the mobile switching center (MSC),
4. the fixed network (Transmission systems) and
5. the PSTN.

Figure 7.1 representing main components of cellular/ wireless communication system is shown below:

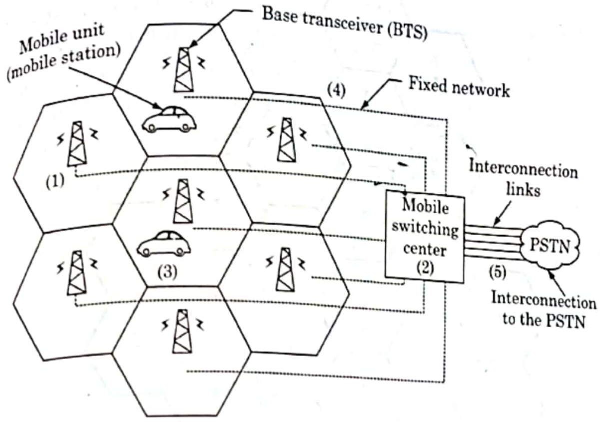


Fig. 7.1 *Five main components of a cellular telephone system.*

7.5 FREQUENCY REUSE CONCEPT

So far we have studied that a given geographical area coverage is subdivided into hexagonal cells where each cell has its own set of channels (or band of frequencies) and a number of channels were required for cellular communications.

But this is not a practical approach to allow different sets of channels to each cell for entire geographical area due to limited range of frequency spectrum for wireless (cellular) communication. Therefore to overcome this drawback, a technique is adopted which uses same set of channels for different cells, the cells are separated from one another by a distance large enough to keep interference levels within tolerable limits. Fig. 7.2 shows frequency reuse concept (N = 7 reuse format). Frequency resuse plan can simply be defined as how technocrats, and engineers subdivide and assign the FCC allocated radio spectrum, throughout the coverage area.

• = Cell base station location

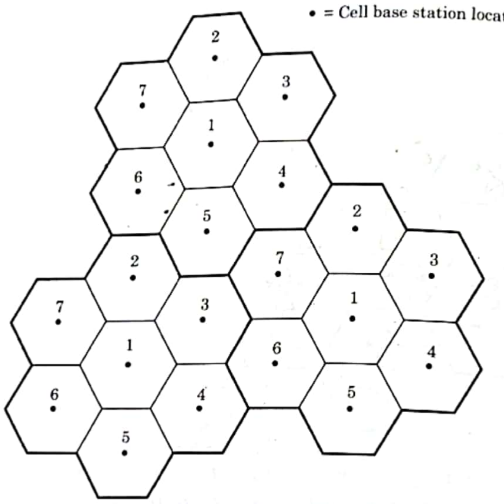


Fig. 7.2 *Frequency Reuse Format (N = 7).*

7.5.1 Why Hexagons are preffered Over Circular and Other Shapes

Now the very first question that comes into our mind is that why cells are made in hexagonal pattern not in circular, triangular or rectangular shape?

The answer to this question is that, hexagons cover the entire geographical region without overlapping and have equal area without any uncovered network. If we use circular

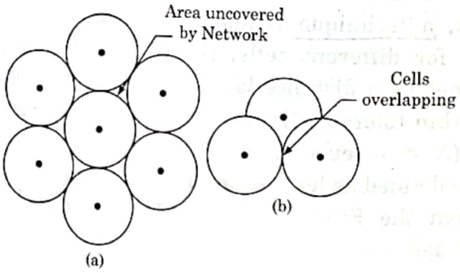


Fig. 7.3 *Circle pattern for cells.*

pattern for a cell then some gap will exist in between adjacent cells that remains uncovered by any. To avoid this gap, circles (or cells) are required to overlap but in that case the set of channels also get overlapped.

If square or rectangle shape is used for a cell then the distance between cells from center to center does not remain same. Fig. 7.4 shows square pattern of cell construction.

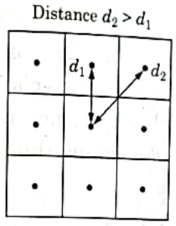


Fig. 7.4 *Square pattern for cells.*

Therefore, hexagons are preferred over circular or square shapes. There is no gap found between any two hexagons as shown in Fig. 7.2. The distance from one center to other center of two nearby hexagons is same and also the hexagons have the largest area over any other shape.

7.6 FREQUENCY REUSE PLANNING

To plan the cells for reuse of frequencies depends on the cluster size of the cell. The number of cells which collectively use the complete set of available frequencies is called a '*Cluster*'. If a cluster consist of N cells and total frequency

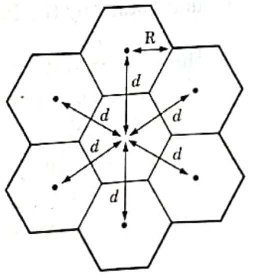


Fig. 7.5 *Cluster size N = 7*

spectrum allocated to that cluster is K then each cell frequency will be K/N. For example — for a cluster size $N = 7$ (total seven cells/cluster) the frequency reuse factor is 1/7 since each cell has one-seventh of the total number of available channels.

The essential issue is to determine the number of cells that must intervene (left) between two cells using the same frequency so that two cells do not interfere with each other.

The consideration that, after how many cells, frequency is to be reused depends upon the co-channel cells. Co-channel cells are those cells which have same frequency. The following procedure is adopted to determine the locatioin of the nearest co-channel cell—

1. Move i cells straight from center.
2. Move j cells counterclockwise (anticlockwise) at 60° turn.

Where i and j are non-negative integers.

The cluster size N is related to i and j by the following expression

$$N = i^2 + ij + j^2 \qquad ...(7.1)$$

Fig. 7.6 shows a cluster size ($N = 19$) for $i = 2$ and $j = 3$.

Cluster size is typically equal to 4, 7, 12 and 19 etc. The value of cluster size indicates that how much interference a mobile or base station (BTS) can tolerate while maintaining a sufficient quality of communication. The effect of cluster size over system can be understood by the following discussion.

1. If N is large then co-channel interference gets minimized because the ratio between cell radius and distance between co-channel cells decrease.
2. If N is small then capacity increases because more clusters are required to cover a given area while inteference also increases because co-channels gets much closer.

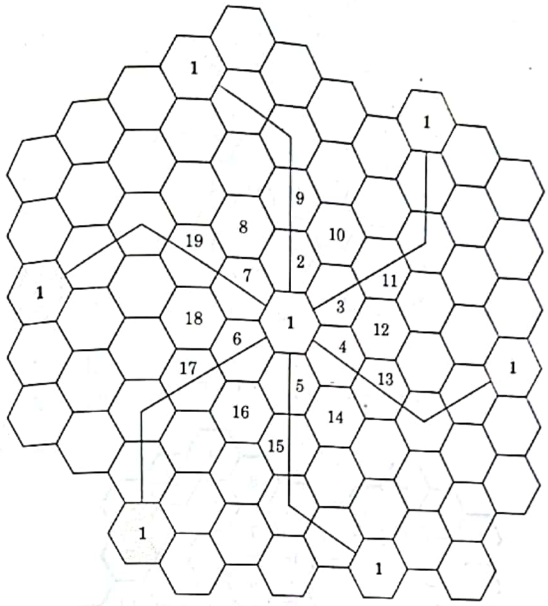
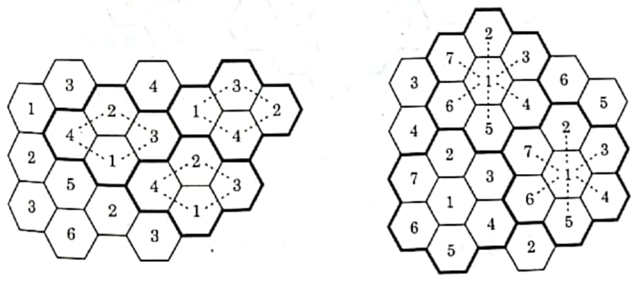


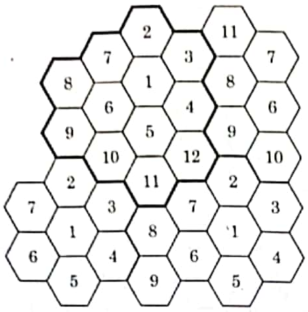
Fig. 7.6 *Co-channel cells for $N = 19$ cluster size.*

Figure 7.7(a b, c, d) illustrates different clusters schemes.

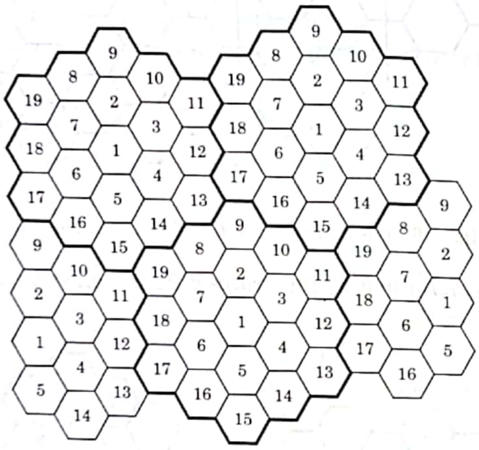


(a) $i = 2$ *and* $j = 0$ ($N = 4$)

(b) $i = 1$ *and* $j = 2$ ($N = 7$)



(c) $i = 2$ and $j = 2$ (N = 12)



(d) $i = 2$ and $j = 3$ $(N = 19)$

Fig. 7.7 *Formation of Various Clusters.*

7.7 FREQUENCY REUSE RATIO OR DISTANCE-TO-REUSE RATIO

The frequency reuse ratio which is also known as distance to reuse ratio or co-channel reuse ratio, defines the geographic distance that is required between cells using identical frequencies in order to avoid interference between the radio transmissions at these cells. It is represented by 'Q',

$$Q = \frac{D}{R} = \sqrt{3N} \qquad ...(7.2)$$

where D = Minimum distance between two co-channel cells

R = Radius of the co-channel cells

and N = Cluster size

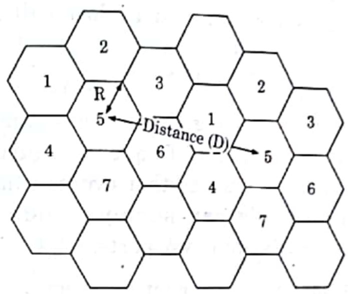


Fig. 7.8 *Distance-to-Reuse ratio in a wireless system.*

The value of Q at different cluster size is given in table 7.1.

Table 7.1: Q/R ratio for various cluster sizes.

Reuse Parameters (i, j)	*Cluster Size* $N = i^2 + ij + j^2$	*Distance-to-Reuse Ratio* $Q = \sqrt{3N}$
$i = 1, j = 1$	3	3.00
$i = 2, j = 0$	4	3.46
$i = 1, j = 2$	7	4.58
$i = 0, j = 3$	9	5.20
$i = 2, j = 2$	12	6.00
$i = 3, j = 2$	19	7.55

7.8 INTRODUCTIION OF DROPPED CALL AND BLOCKED CALL

Before we discuss further, the difference between the dropped call and blocked call should be known. Dropped call may be exist due to poor signal strength of the assigned voice channel. During a connection, because of interference or weak signal spots in certain areas, if the BS is unable to maintain minimum required signal strength, then the call gets dropped and the MTSO is informed. In simple words, a dropped call can be defined as after the call is established but before it is properly terminated.

While blocked call is the call that can not mature due to congestion of traffic or if there is a possibility of a call drop due to unavailable voice channels. This is referred as blocked call. Blocked calls also referred as lost calls.

7.9 CHANNEL ASSIGNMENT STRATEGIES [2009-10]

The main objective of using channel assignment strategies is to optimize utilization of frequency reuse scheme and minimization of inteference so that overall chanenl capacity can be increased. We can simply divide the channel assignment strategies into two parts:

1. Fixed Channel Assignment Strategy
2. Dynamic Channel Assignment Strategy

It is quite important to know which of the two strategies is being used because it impacts the whole performance of the system especially during hand-off cases.

7.9.1 Fixed Channel Assignment Strategy

Fixed channel assignment strategy depicts that a fixed set of frequencies (voice channels) is allocated to each cell. Maximum number of calls that can be attempted depend on the number of voice channels. If all the channels in a cell are found occupied then the call is *blocked* and no service will be delivered to the subscriber.

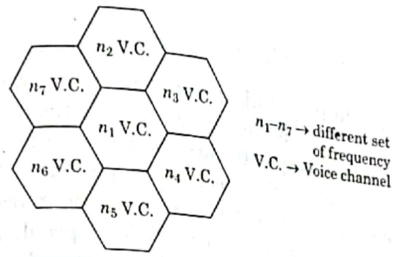


Fig. 7.9 *Fixed Channel Assignment Strategy.*

In this strategy, an approach is sometimes adopted that is known as *borrowing approach*. In this approach, one cell is allowed to borrow some voice channels from its neighbouring cell under the control of mobile switching center (MSC). Main point to note in this approach is that neighbouring cell should not be disturbed or interfereed any way by borrower cell.

7.9.2 Dynamic Channel Assignment Strategy

As its name suggests it is dynamic in nature or in other words, no fixed set of voice channel is present in this strategy. When request of a call is made through a cell then this request is passed to the MSC via BSC. The MSC then allocates a voice channel to the requesting cell.

The main advantage of this strategy is that blocking probability of a call is reduced in this case which increases the trunking capacity of the system.

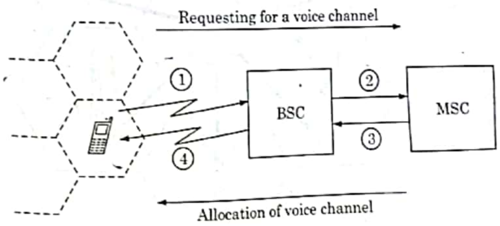


Fig. 7.10 *Dynamic channel assignment strategy.*

7.10 HAND-OFF STRATEGIES

Before going into its detail, first we must understand "*What Hand-off actually is?*" In the cellular systems the main problem was to transfer a set-up call from one base station to another base station without getting disconnected because the working frequency get changed when user is at bounaraly side of one cell and going towards other cell. This problem is solved by Hand-off process. Hand-off can be explained as if a user havng a mobile phone is in conversation and going-from one place to another place then there may be a number of cells convering that geographic area which may lie in the path of user, then the base station of one cell transfers this cell to other the base station of other cell as and when the user enters into the area of other cell.

Fig. 7.11 shows the call hand-off from one cell base station to another cell base station while maintaining the call connection to the cellular system. Generally hand off is required in two situations. In these situations, the cell site receives weak signals from the mobile unit. These situations exist,

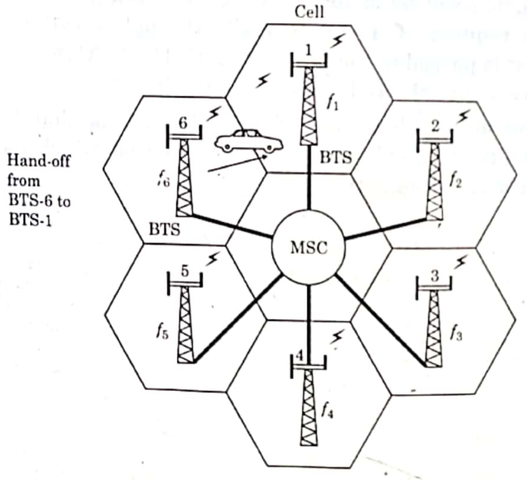


Fig. 7.11 *Call hand-off.*

1. At the cell boundary
2. When mobile unit is reaching towards the lower signal strength areas within the cell site.

The handoff processing scheme is an important task for any successful mobile system. A susccessful hand off indicates that serving call should not be dropped out. Figure 7.11 shows step-by-step procedure of call hand-off prrocessing.

Initially, the user/subercriber was in the cell 6 having opertting frequency f_6. Here, he set up a call and travel

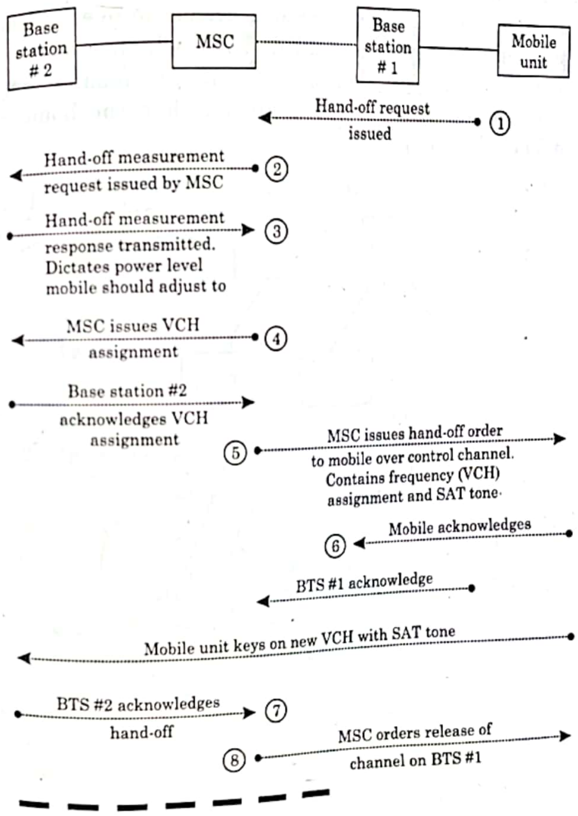


Fig. 7.12 *Call hand-off signaling process.*

Scanned with CamScanner

towards cell 1. At the boundary of cell 6 and cell 1, if hand-off is not activated then continued call gets disconnected. The operating frequency gets changed from f_6 to f_1. This can be understand and as user enters into cell 1 then cell 1 base stations signal are more strong than cell 6 base station, which are received by the mobile.

In the first generation analog cellular systems, the signal strength was measured by the base stations (BTS) under the control of MSC. One more unit known as "*Locator Receiver*" was used to determine the signal strengths of mobile users of neighbouring cells. These locator receivers were established in each base station. The final decision, whether a handoff is required or not, is taken by MSC. If the signal strength of users in neighbouring cell is greater than the home cell then handoff is required.

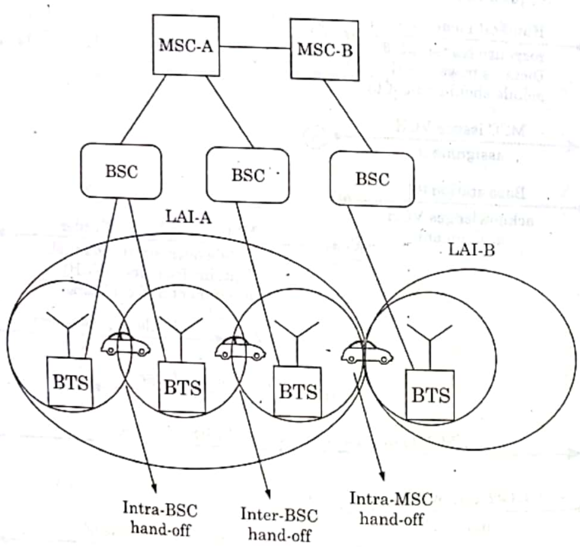


Fig. 7.13 *Different types of handoffs*

In second generation sustems, hand-off does not depend on base stations but it is decided by mobils stations itself. This type of handoff is known as Mobile Assisted Hand Off (MAHO). MAHO is required when the power received from neighbouring cell exceeds the power received from the current cell.

Generally, hand-off is categorized into three types as shown in Fig. 7.13.

1. Intra – BSC Hand-off— In which only BTS changes from cell to cell but BSC remains same.
2. Inter – BSC Hand-off— In which including BTs, BSC also changes from one cell to another but MSC remains same.
3. Inter – MSC Hand-off — In which BTS, BSC and MSC all get changed at movement of mobile unit from one cell to another.

Advantages of Hand-off:

1. Avoids dropped calls when mobile unit moves from one cell to another.
2. Improves load balancing between adjacent cells. 92
3. Improves global interference level.
4. Makers wireless conversation more reliable.

7.11 INTERFERENCE

Interference can be understood as interaction of radio signals that cause noise. Interference and system capacity, both terms are inversely proportional to each other. If interference of any system increases then its capacity decreases. Interference is simply defined as a disturbance during conversation or during establishment of a call in cellular radio systems.

Sources of Interference

1. Leaky energy of non cellular systems into cellular system.
2. A call in progress at the cell boundary
3. Other base stations operating at same frequency
4. Another mobile unit in the same cell.
5. Cross talk on voice channels.

Disadvantages of Interference

Interference is the major limiting factor for wireless cellular systems. Some pronounced disadvantages of inteference are,

1. Missed calls rate increases
2. Dropped calls rate increases
3. Errors enter in digital signaling.
4. Noise increases in form of humming sound.

Types of inteference

Interaction of signals of one cell may be either due to its reused frequency cell in other clustur or due to its neighbouring cell. Therefore,

Interference is categorized into two parts:

1. Co-channel inteference
2. Adjacennt channel inteference

Some other factors may also affect the working of a cell like as—Heavy magnetic field or electric field, lightenning etc. But here we will concentrate only at the interference due to interaction of radio frequencies.

7.11.1 Co-channel Inteference

Co-channel cells are those cells which uses same (identical) set of frequencies in a given coverage area. The interference between signals of these cells is called as 'Co-channel inteference'.

Co-channel inteference occurs when the same carrier frequency reaches the mobile unit receiver from two separate transmitters (base stations). Fig. 7.14 shows co-channel cells for $N = 7$ cluster format. Here the cells having the same numbers use the same set of frequencies.

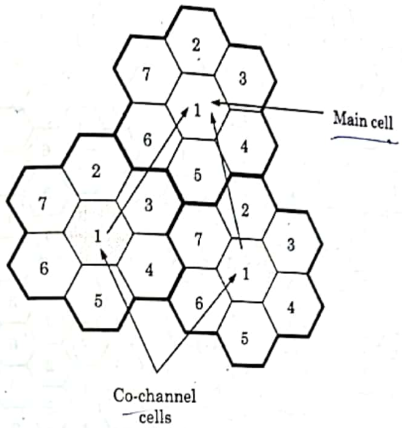


Fig. 7.14 *Illustration of Co-Channel cells responsible for co-channel inteference.*

Key Note: If cluster size increases then co-channels get further apart or distant. Therefore co-channel interference can be reduced by maintaining proper distance in between the co-channels to provide sufficient isolation.

Generally, co-channel cells are located in tiers. Tier is a large hexagon that is formed by connecting nearest co-channel cells. A cell is surrounded by $6n$ co-channel cells for nth tier (in $N = 7$ cluster size). For example, if $n = 1$ (for first tier) than co-channel cells are $6 \times 1 = 6$ in first tier. If $n = 2$ then number of co-channel cells will be 12 in second tier. Fig. 7.15 shows the first tier and second tier co-channel cells.

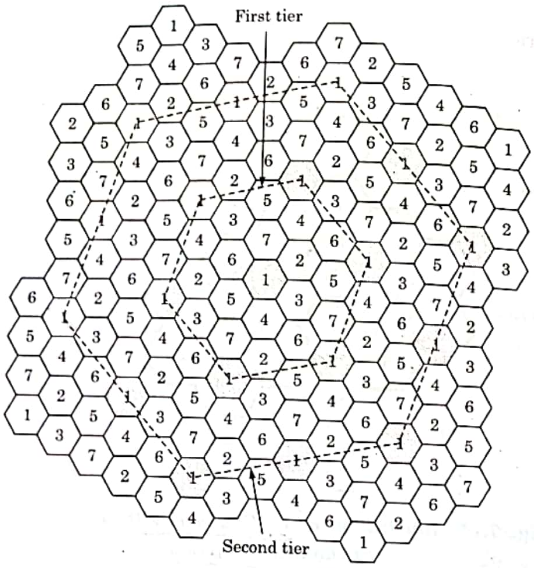


Fig. 7.15 *Different co-channel cells forming first & second tier.*

7.11.2 Adjacent Channel Interference [2009-10]

Adjacent channels are those channels which have less separation in frequency from the desired channel. The inteference resulting from signals of adjacent channels is known as "*Adjacent Channel Inteference.*" Adjacent channel inteference is caused by the inability of a mobile phone to filter out the signals (frequencies) of adjacent channels assigned to nearby cell sites. If the receiver is not strict to allow only its own pass band but permit some nearby frequencies also then adjacent channels traffic do interfere in the current cell. Fig. 7.16 shows adjacent channel and desired main, channel.

Key Note: The main drawback of adjacent channel inteference is near-far problem. Near-far problem is when a near-by transmitter captures the subscriber's receivers that is very close in frequency range while the subscriber attempts to receive a base station on the desired channel.

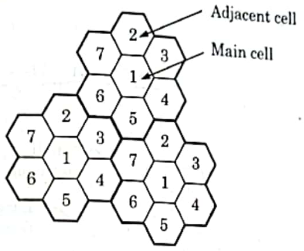


Fig. 7.16 *Illustration of Adjacent Channel Cells responsible for adjacent channel inteference.*

To avoid adjacent channel inteference,

1. careful filtering is required.
2. Frequency separation between each cell should be maximize.
3. Use separate uplink and downlink frequency.

7.12 SYSTEM CAPACITY vs. INTERFERENCE

So far we have discussed about different inteferences. Now we will discuss how inteference impacts system capacity.

7.12.1 Effect of Co-channel Inteference

If the mobile unit is in motion and reaches towards the cell boundary (point z), then it experiences a worst case co-channel inteference on the forward chanel i.e. from base station to the mobile unit. Fig. 7.17 shows different co-channel cells for a cluster size $N = 7$.

Here, Radius of each co-channel cell is denoted by r and the distance between centers of the nearest co-channel cells is D. Now, the *co-channel reuse ratio (Q)* can be defined as, Co-channel reuse ratio

$$Q = \frac{D}{R} \qquad ...(7.3)$$

D – Distance
R → radius

For a hexagonal cell geometry, Q is also related with the cluster size

$$Q = \sqrt{3N}$$

therefore, from equation (7.3) and (7.4) ...(7.4)

$$Q = \frac{D}{R} = \sqrt{3N} \qquad ...(7.5)$$

or

$$\frac{D}{d} = \sqrt{N}$$

where d is the distance between centers of adjacent cells ($d = \sqrt{3}R$)

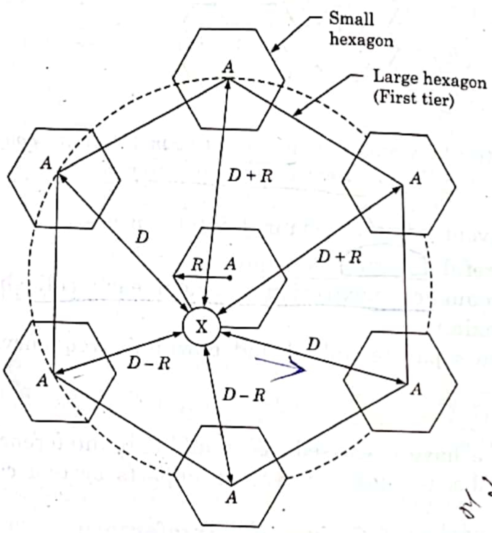


Fig. 7.17 *Illustration of the first tier of co-channel cells for a cluster size of N = 7.*

If cluster size (N) is small then system capacity increases due to small value of Q. But if Q is large then it improves transmission quality due to smaller level of co-channel inteference (as D becomes large). Therefore, the value of Q must be so chosen that capacity and transmission quality gets maximized.

7.12.2 Effect of Adjacent Channel Inteference

As we know that cluster size (N) is inversely proportional to frequency reuse factor. For example — If cluster size $N = 7$, then the frequency resuse factor is 1/7 since each cell contains 1/7th of the total number of available channels.

Therefore, for a small value of cluster size the frequency reuse factor becomes large which indicates insufficient separation between the adjacent channels. It may cause adjacent chennel inteference to exceed the tolerable limits. thus, overall system capacity gets reduced. If there are two mobile units in a cell, first one is close to base station and second is distant from the base station, then to avoid adjacent channel inteference at distant mobile unit, very accurate base station filters are required.

7.13 IMPROVING COVERAGE AND CAPACITY IN CELLULAR SYSTEMS [2010-11]

With each passing day, the number of subscribers demanding for wireless services is increasing. This increment in the number of users generates a need to increase the channels to properly support the users. To fulfil this requirement, some techniques have been invented that help in increasing more channels/unit coverage area. Some these are:

1. Cell Splitting
2. Cell Sectoring
3. Micro cell zone concept
4. Increasing number of repeaters

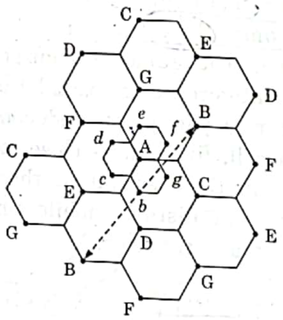
Description of these techniques are given as below.

7.13.1 Cell Splitting [2009-10]

own base station

As its name suggests, splitting means to divide something into smaller parts. Cell splitting means a cell is divided into smaller cells. Cells in areas of high usage can be split into smaller cells. Each smaller cell consists of its own base station therefore number of base station increases but the main advantage is reduction in antenna height and transmitter power due to small coverage area in case of splitted cell.

The increased number of cells would increase the number of clusters over the coverage region, which in turn would increase the number of channels and thus capacity increases in a given coverage area whereas due to smaller size of cell the hand-off becomes much more frequent. Cell splitting technique is shown in Fig. 7.18.



Lower base station
reduce antenna
height

Fig. 7.18 *Cell Splitting.*

Note: New smaller cells (b - g) have same frequency as larger cells (B-G).

As shown in Fig. 7.18, to maintain proper cell splitting the base stations labeled A to G are placed at corners of the cells. New cells are added according to frequency reuse plan of the system. New smaller base stations labeled b - g are placed between two larger base stations having same frequency. For exp. — 'b' is placed at the mid point of two 'B' base stations.

Advantages of Cell Splitting:

1. Number of channels per unit area increases.
2. System capacity increases.
3. Antenna height is reduced.
4. Transmitter power is reduced.

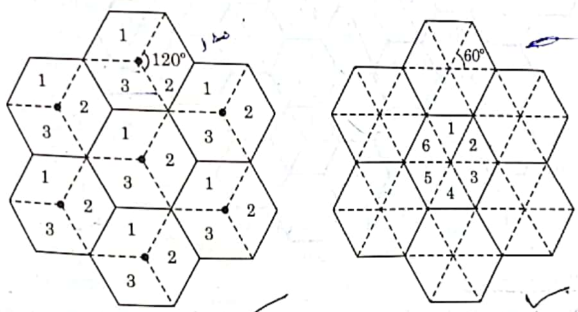
Disadvantages of Cell Splitting:

1. Number of base stations increases.
2. Overall cost of the system increases.

7.13.2 Cell Sectoring

In the sectorization technique, neither more base stations are required nor cell division into micro cell is done, but each cell is divided into sectors to increase the system capacity by increasing the signal to inteference ratio (SIR) (or decreasing the inteference level). SIR is increased by using directional antennas at each sector. As we know that directional antennas radiate in a particular direction not in all directions as done by omnidirectional antennas. Thus, directiional antennas reduces interference and therefore increses SIR. Here, each cell is divided into more than one sector having one directiional antenna at each sector. The factor by which co-channel inteference is reduced depends on the amount of sectoring used. Typically the division of 3 or 6 cells per sector allowed. Fig. 7.19 shows sectoring at different angles.

Sectoring technique uses more than one antenna per base station or per cell. The available channels in the cell are subdivided and each division is dedicated to a specific antenna. For example - In 120° sectorization (for cluster size $N = 7$), each cell is subdivided into three sectors and each sector have its own directional antennna and channel frequencies.



(a) 120° sectoring (b) 60° sectoring

Fig. 7.19 *Sectoring at different angles.*

Fig. 7.20 shows how 120° sectoring reduces inteference from co-channel cells. Before sectoring, six co-channel cells intefere with the center cell but after sectoring (120°) only two co-channel cells are allowed to intefere. Co-channel cell(1) of cluster A and B gets interfere due to main cell after sectorization while other co-channel cells don't receive interference because these are at anti side of sectorization and not lie in the interference area of main cell. In practice, the reduction in interference enables the designers to reduce the cluster size *N*, and therefore a small value of N increases the capacity and provide an additional degree of freedom in assigning channels.

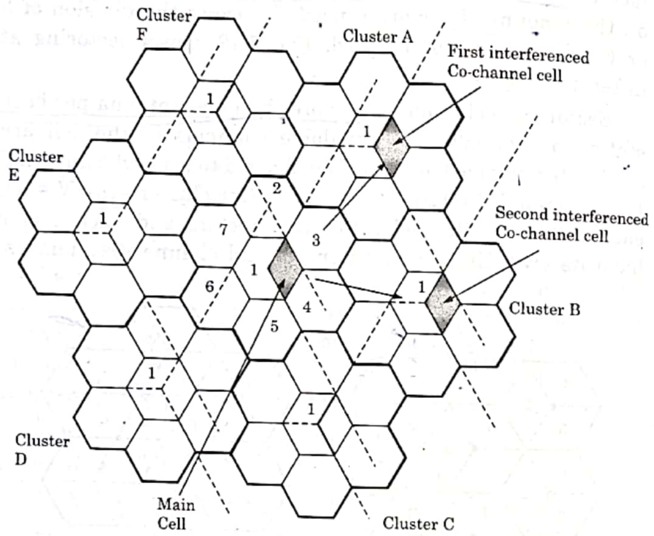


Fig. 7.20 *Reduced interference in Co-channel cells (Showing by no. 1) by using sectorization.*

Advantages of Sectoring

1. Reduces co-channel inteference
2. Increases capacity by increasing Signal to interference ratio (SIR).
3. Cell radius gets unchanged (as it was half in splitting technique by introducing new micro cells).

Disadvantages of Sectoring

1. Number of antennas per cell gets increased.
2. Trunking efficiency decreases due to channel sectoring at the base station because available trunked channel pool is divided into several smaller pools.
3. Sectoring makes hand-off more hectic (typical) because mobiles crossing the boundary of one sector to another sector within the same cell requires hand-off.

7.13.3 Micro Cell Zone Concept

This technique is being adopted in most cellular and personal communication systems. Micro cell zone concept is quite similar to sectoring but all the drawbacks faced during sectoring are removed in microcell zone concept. This proposal is based on microcell concept for seven cell reuse ratio.

A cell is made using many zones and a single base station. Each zone is connected by either coaxial cable, fiberoptic cable or microwave link to the base station via zone selector. Each base station has its own channel set that is collectively used by the cell zones in time and space pattern. This means same channel can be retained by a mobile travelling from one zone to another within the cell, by simply switching the channel to the second zone using zone selector. This removes the requirement of hand-off from one zone to another. Fig. 7.21 shows the microcell zone concept.

7.14 COMPARISON AMONG CELL SPLITTING, CELL SECTORING, MICOR CELL ZONE CONCEPT, INCREASING NO. OF REPEATERS

Table 7.2

S.N.	Parameters	*Cell splitting*	*Cell sectoring*	*Micro cell Zone Concept*	*Increasing no. of repeaters.*
1.	Process	Each cell is divided into smaller radius cells.	Each cell is divided into sectors of equal area having centred at mid of the main cell.	Each cell is formed using many zones.	Reeaters are used to cover more coverage area.
2.	Base Station	Each samller cell requires new base station.	No more base stations are required.	Each cell has only one base station.	Repeaters are required.
3.	Interference	Interference gets increased due to nearer co-channel cells.	Co-channel Interference is reduced.	Interference is reduced.	Interference is ncreased due to amplification.
4.	System Capacity	System capacity increases due to increase in the no. of cluster.	System capacity increases by increase in the signal to Interference Ratio (SIR).	System capacity increases without any degradation in trunking efficiency.	System capacity remains unchanged.
5.	Radius of cell	Radius of cell decreases.	Rading of cell reamins unchanged.	Radius of cell increases.	No effect at radius of cell.
6.	Cost	Cost increases due to new base stations.	Cost Increases due to more antennas.	Case decreases due to less base stations.	Cost increases due to repeaters.

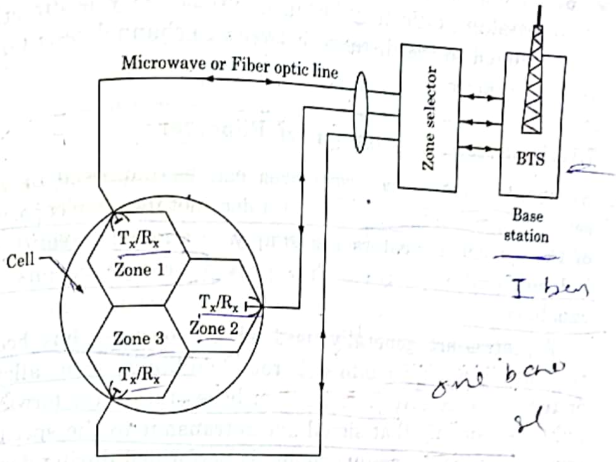


Fig. 7.21 *The Micro Cell Zone Concept.*

Inteference is reduced in this technique because a given channel is working only in that zone where the mobile is traveling.

Microcell technique is very useful in congested areas, long highways, inside large buildings etc.

Advantages of Micro cell Zone Concept

1. Only one base station can serve for more than one zone.
2. Any base station channel may be assigned to any zone using zone selector.
3. Interference is reduced since a large central base station is replaced by several lower powered transmitter on the edges of the zone.
4. Co-channel cells may be formed in the normal fasion that uses the same frequency.
5. Improves the signal quality by decreasing the co-channel inteference.

6. System capacity increases without any degradation in trunking efficiency because the capacity is directly related to the distance between co-channel cells (and not zones).

7.13.4 Increasing Number of Repeaters

By using repeaters, coverage area can be improved or we can say range can be extended but it does not increase capacity of the system. Repeaters are simply '*Radio retransmitters*' bidirectional in nature, that provide range extension capabilties.

Repeaters are generally used where coverage has been traditionally weak like into and around buildings or in valleys or tunnels. It receives signals from base station (in forward link) then amplify that signal and retransmit to the specific coverage region. Same functioning is performed during down link (signals to base station). The main drawbback is that it amplify the noise and inteference along with the signals. Therefore a care must be taken to properly place the repeaters to minimize the noise and inteference.

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