Wireless and Mobile Networks

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Chapter 3

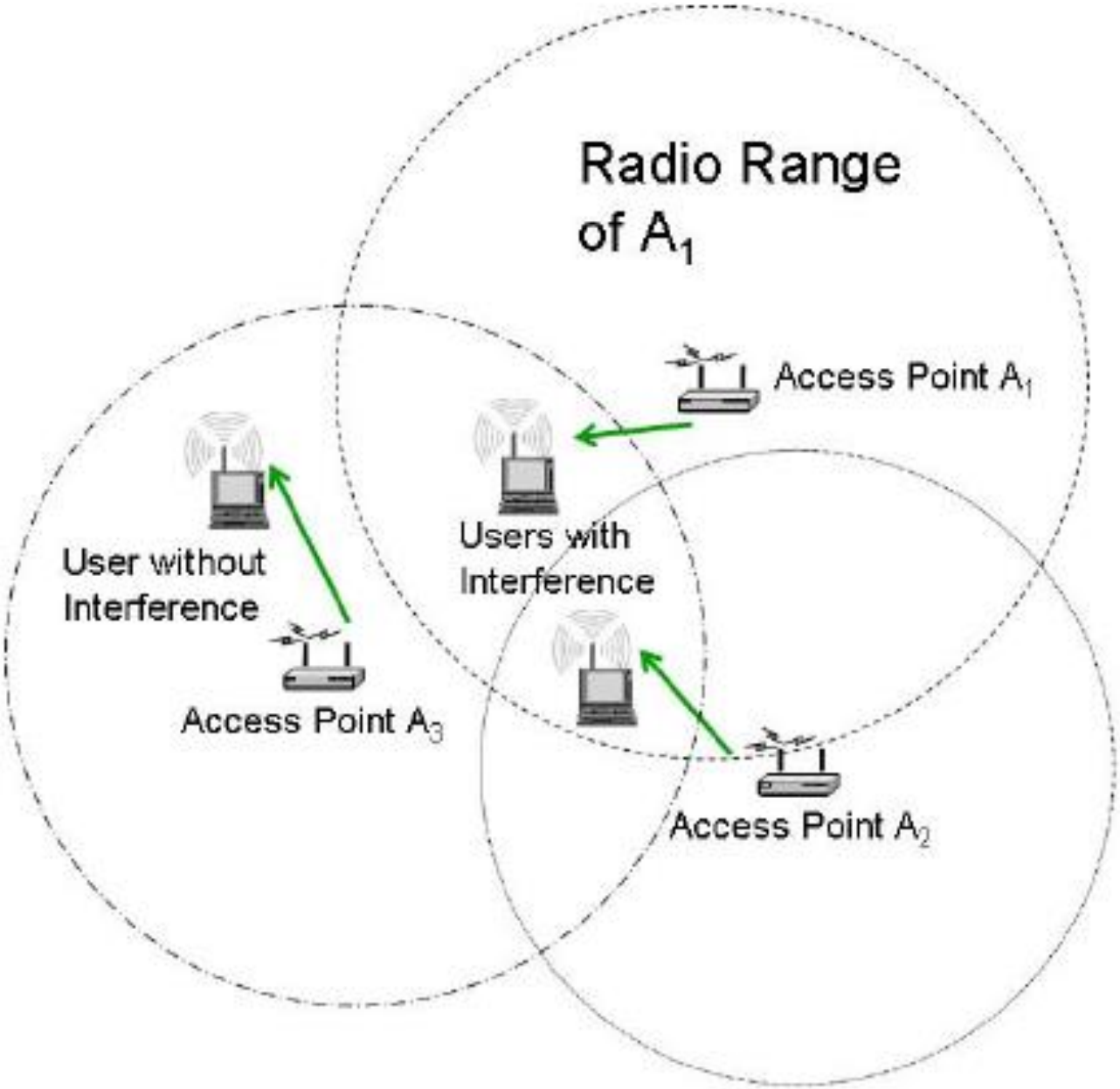
Mobile Networks

Interference Management

Frequency Reuse is a technique for using a specified range of frequencies more than once in the same radio system so that the total capacity of the system is increased without increasing its allocated bandwidth. Frequency reuse schemes require sufficient isolation among the signals that use the same frequencies so that mutual interference among them is controlled at an acceptable level.


1
2
1
2
6
7
3
Frequency re-use
6
7
3
5
4
1
2
5
4
1
2
6
7
3
1
2
6
7
3
5
4
6
7
3
5
4
5
4

Managing interference from other users sharing the same frequency bands has been the key driver for mobile wireless communications. Interference in networks could be managed by simply orthogonalizing the users in the time–frequency plane, i.e., through the use of time-division multiple-access (TDMA) or frequency-division multiple-access (FDMA), or some combination of the two. Interference between base stations operating in the same frequency band was managed by ensuring that they are geographically far apart, again akin to the way in which radio stations operating in the same frequency band are placed.


Radio Range
of A_1
Access Point A_1
User without
Interference
Users with
Interference
Access Point A_3
Access Point A_2

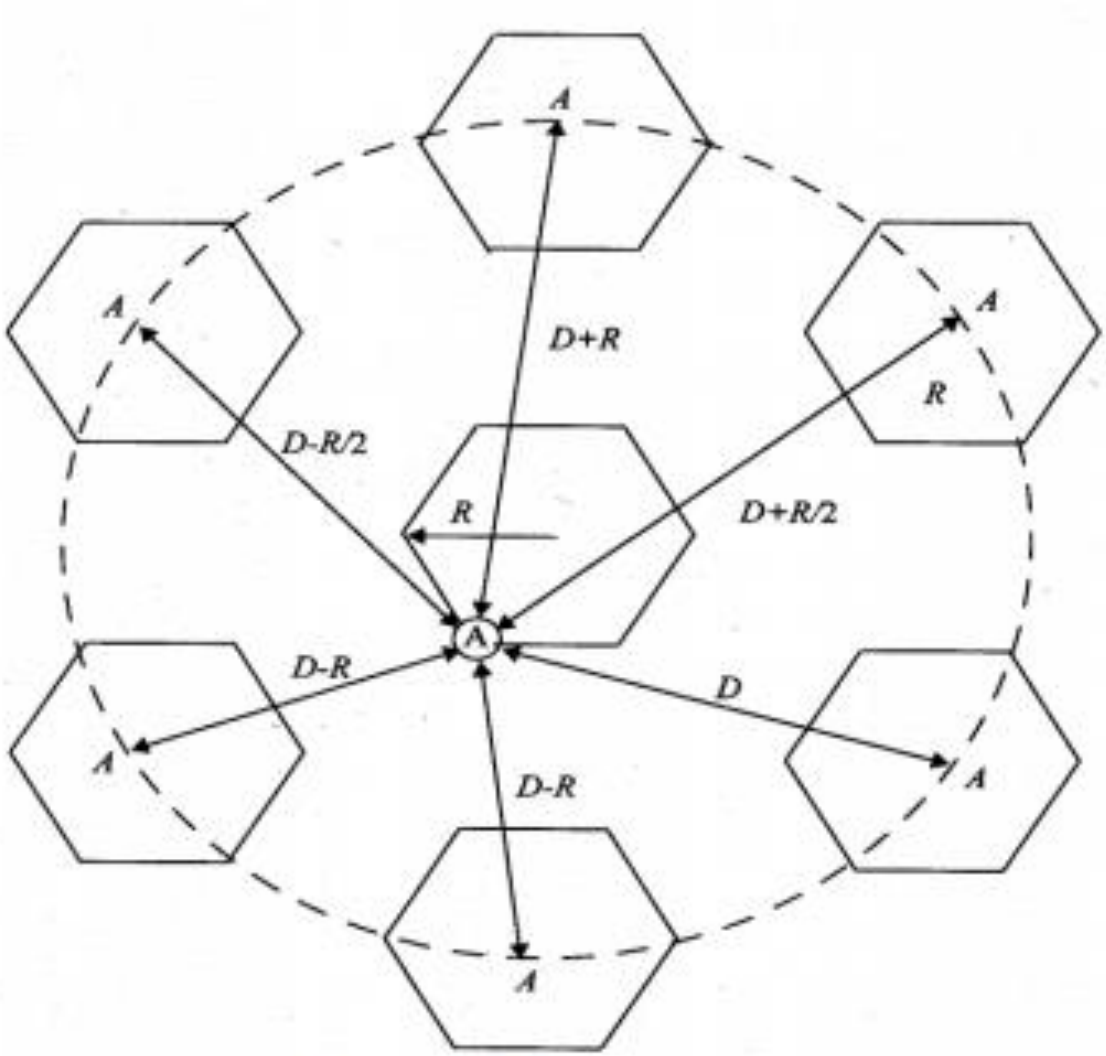
The sources of the interference may be:-

- Another mobile station in the same cell.
- A call in progress in a neighboring cell.
- Any non-cellular system which inadvertently leaks energy into the cellular frequency band.
- Other base stations operating in the same frequency band.

We generally **classify the concept of interference** into the following types depending on how the noise signal causes a disruptive modification in the message signal.

1. Co channel Interference
2. Adjacent Channel Interference
3. Self Interference
4. Multiple Access Interference
5. Inter-symbol Interference

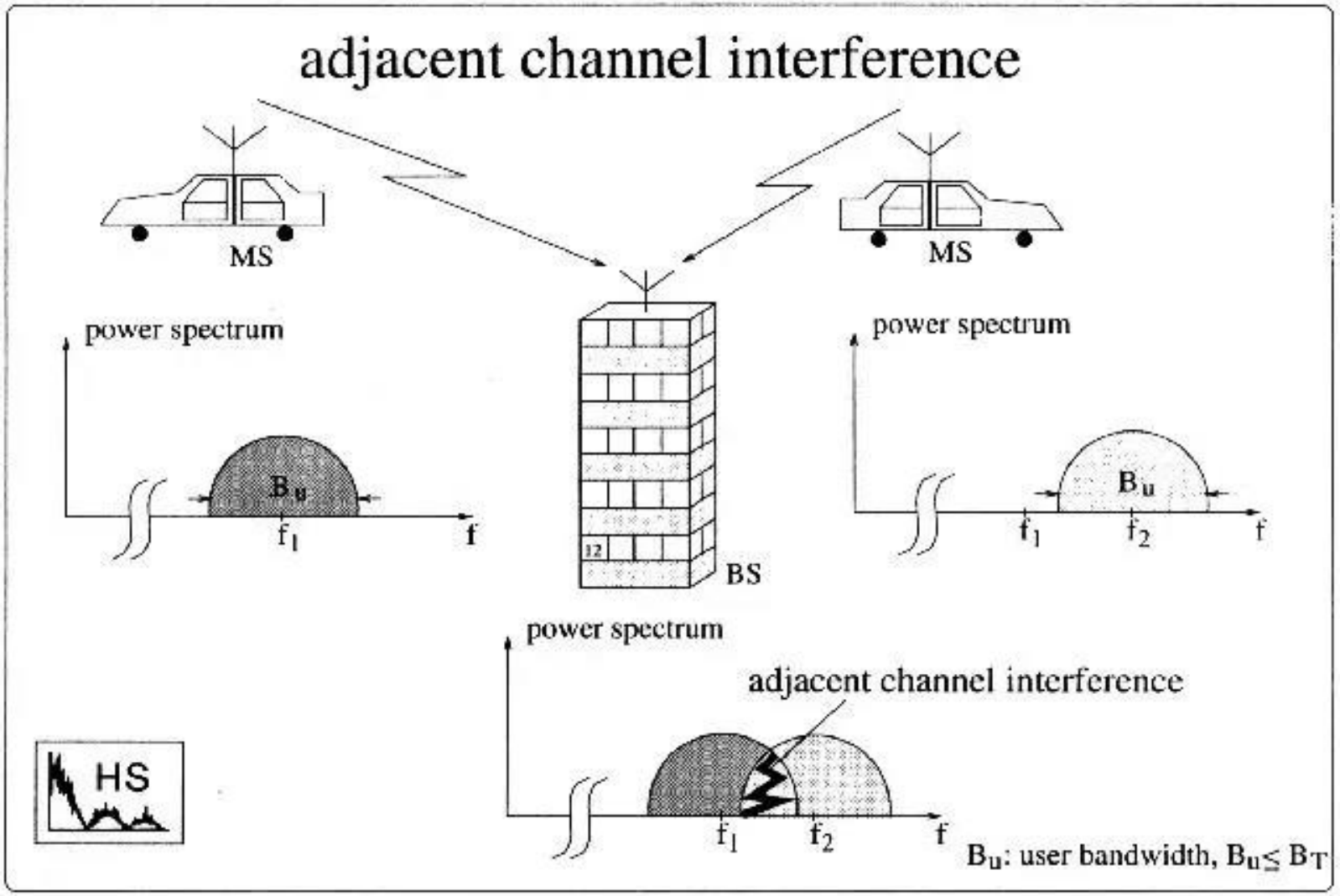
1- Co-channel interference (CCI) between links that reuse the same frequency band (channel). It is also referred to as inter-cell interference in cellular systems. The effect of CCI may be minimized by employing fixed frequency re-use patterns. As CCI occurs only when the message signal and the unwanted signal are of the same range of frequencies, this essentially means that the transmitter transmitting the unwanted signal is located somewhere far away and is not in the adjacent cell.



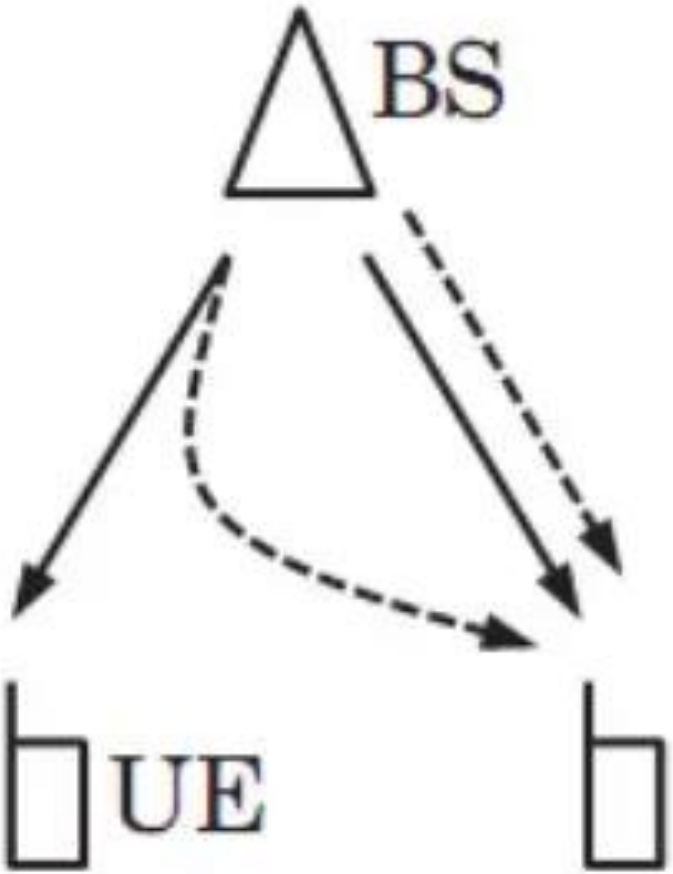
Co-channel Interference

2- Adjacent channel interference (ACI) is the interference induced between links that communicate in the same geographical location using neighboring frequency bands. A transmitter occupying a certain frequency band also leaks energy on frequency adjacent to that band. The out-of-band emissions are perceived as interference by other receivers. ACI is not as serious as CCI and can be easily brought to a minimum (definitely not eliminated) by managing the split of the frequency spectrum such that there exists a distinct "gap" between two adjacent channels. This "gap" is known as the guard band as it prevents the two ranges of frequencies on either side from interfering with each other.

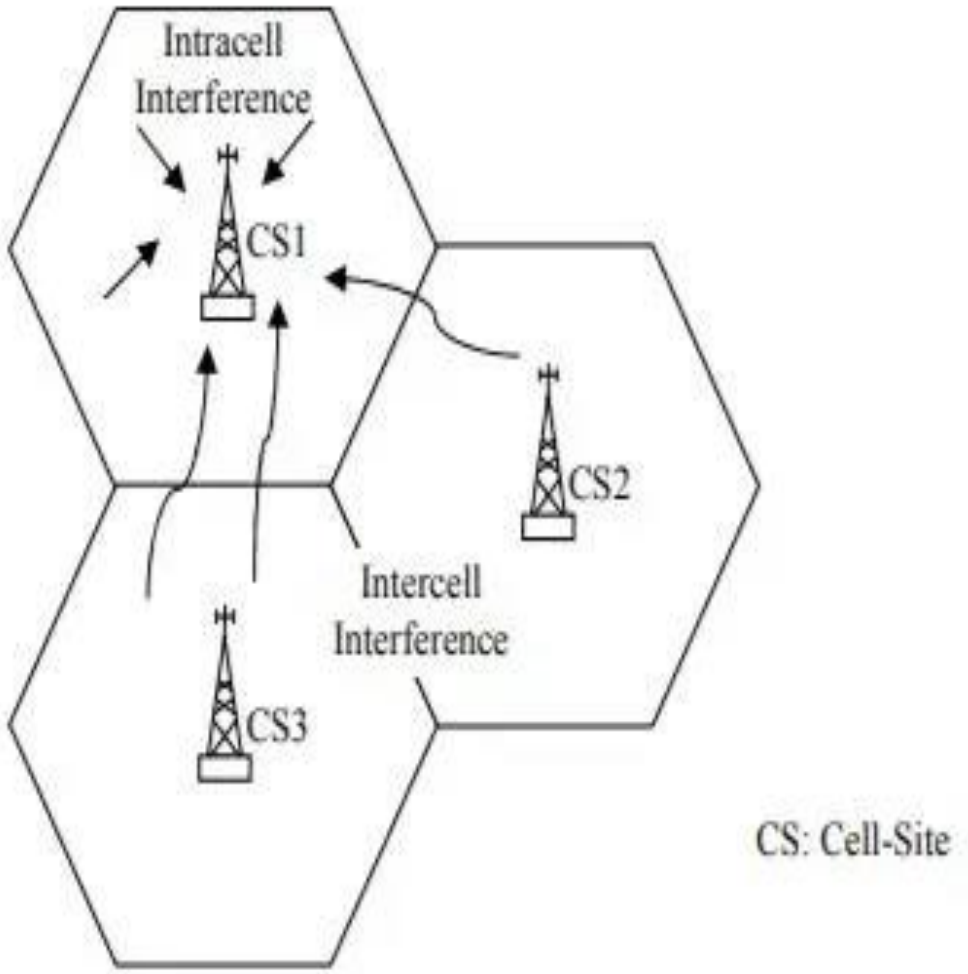
adjacent channel interference



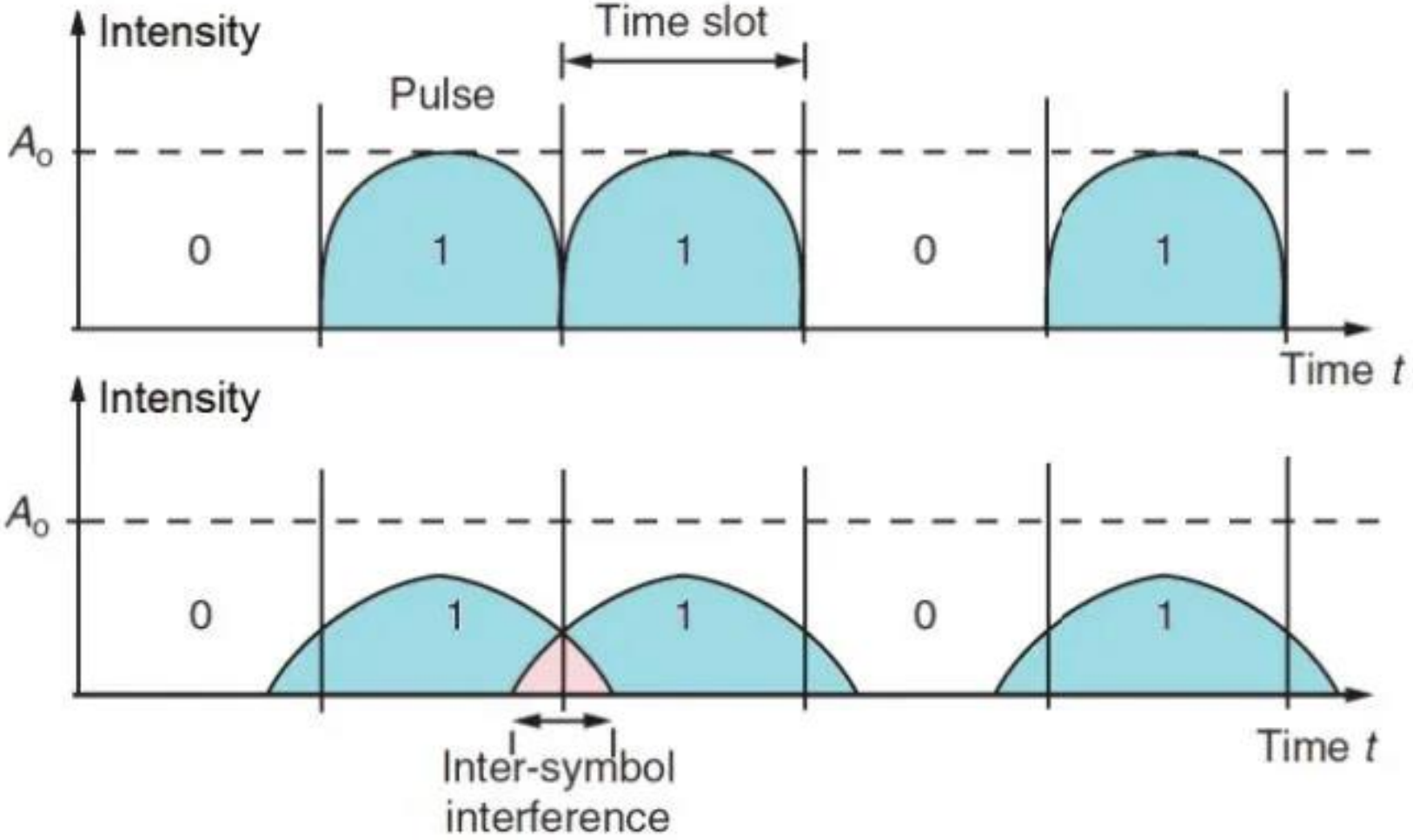
3- Self-interference (SI) is due to interference induced among signals that share a transmitter. The amount of interference induced depends on the modulation type (such as OFDM) in use. Non-linearities in the transmitter and receiver, such as amplifier non-linearity (where the amplifier present does not show a constant gain for a range of frequencies), may also be a source of self-interference. Interference between the uplink and downlink transmissions in a duplex system may also be classified as self-interference, as it occurs among signals on the same two-way connection.


BS
UE

4- Multiple Access Interference (MAI) results from multiple users accessing the same range of frequencies on the same channel. In CDMA systems, adjacent cells reuse the ranges of frequencies available, and hence this type of interference is predominant in the CDMA systems. MAI can prove to be a significant problem if the power level of the message signal is significantly lower (mainly due to distance) than the power level of the interfering user.


Intracell
Interference
CS1
CS2
Intercell
Interference
CS3
CS: Cell-Site

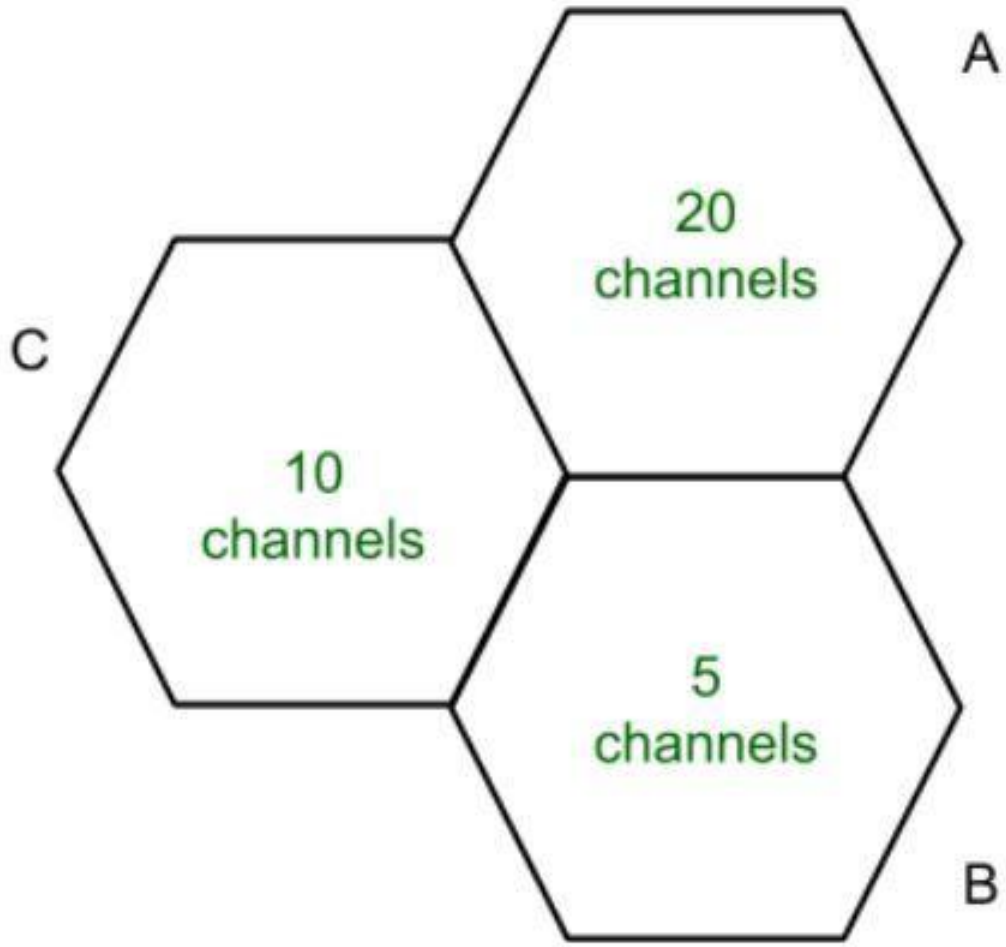
5- Inter-Symbol Interference (ISI) results from the spreading of the pulse of bits beyond its allotted time interval, which causes it to interfere with the neighboring pulses. In other words, inter-symbol interference is a form of distortion of a signal in which one symbol, which essentially refers to one or several transmitting bits, interferes with subsequent symbols. This is a threat to look out for as the previous symbols act just like external noise, making the communication less reliable.


Intensity
Time slot
Pulse
A_o
0
1
1
0
1
Time t
Intensity
A_o
0
1
1
0
1
Time t
Inter-symbol
interference

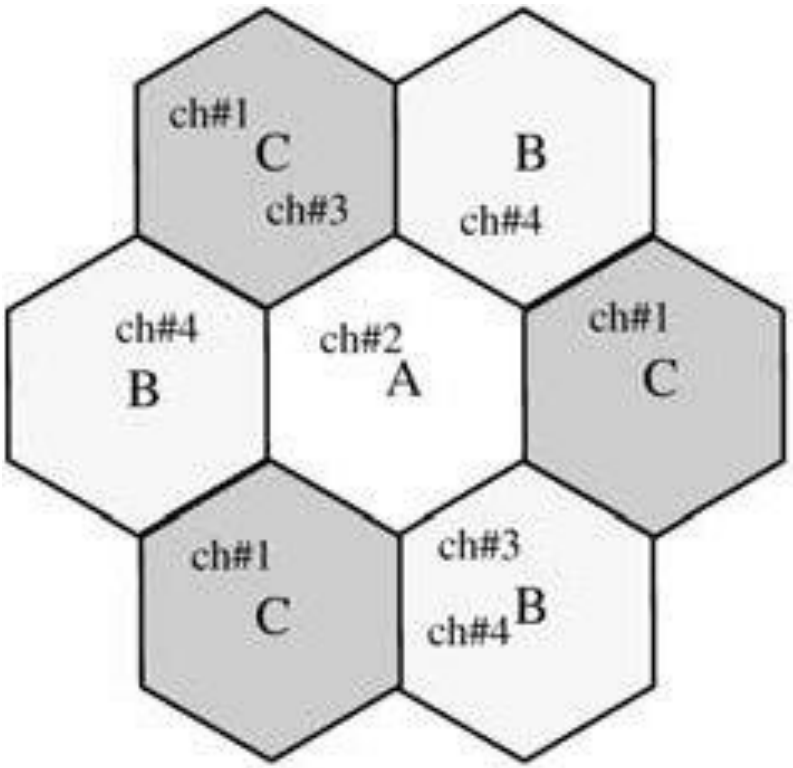
Channel Assignment

The channel assignment problem is a complex problem which requires that under certain constraints a minimum number of channels have to be assigned to mobile calls in the wireless mobile system. Channel assignment problem involves assigning frequencies to each radio cell in such a way that a set of constraints is satisfied. These include the limited number of available frequencies in the radio spectrum as well as the traffic constraints corresponding to the minimum number of frequencies indispensable for covering communication between mobile devices moving in a particular cell

1- Fixed Channel Assignment (FCA): is a strategy in which fixed number of channels or voice channels are allocated to the cells. Once the channels are allocated to the specific cells then they cannot be changed. In FCA channels are allocated in a manner that maximize Frequency reuse. If all channels are occupied and user make a call then the call is blocked. Borrowing Channels handles this type of problem. In this cell borrow channels from other cells.

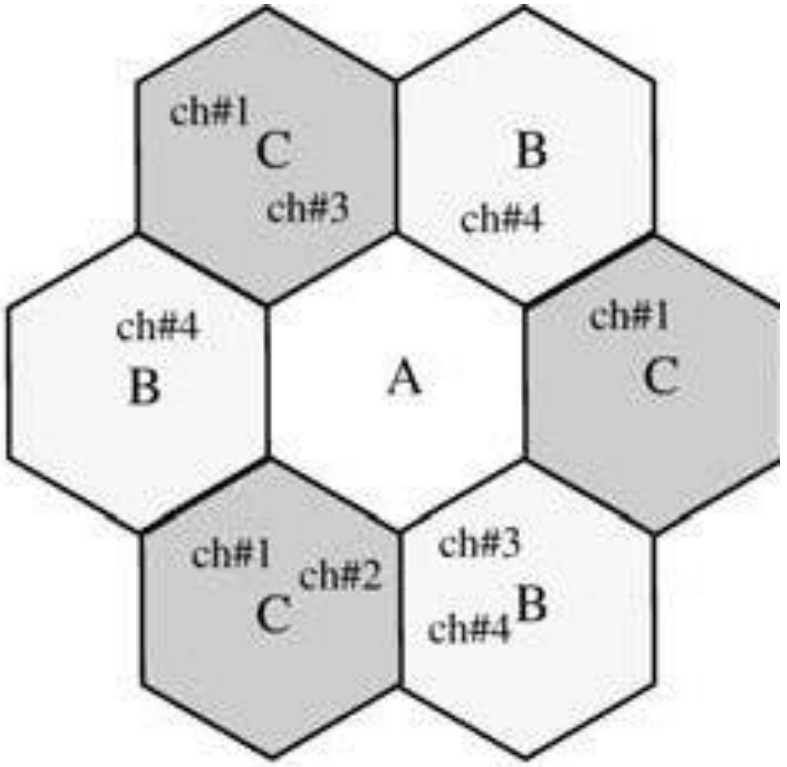

A
20
channels
C
10
channels
5
channels
B

2- Dynamic Channel Assignment (DCA): is a strategy in which channels are not permanently allocated to the cells. When a User makes a call request then Base Station(BS) send that request to the Base Station Controller (BSC) and Mobile Station Center(MSC) for the allocation of channels or voice channels. This way the likelihood of blocking calls is reduced. As traffic increases more channels are assigned and vice-versa.



Total available number of channels = 4

(a)



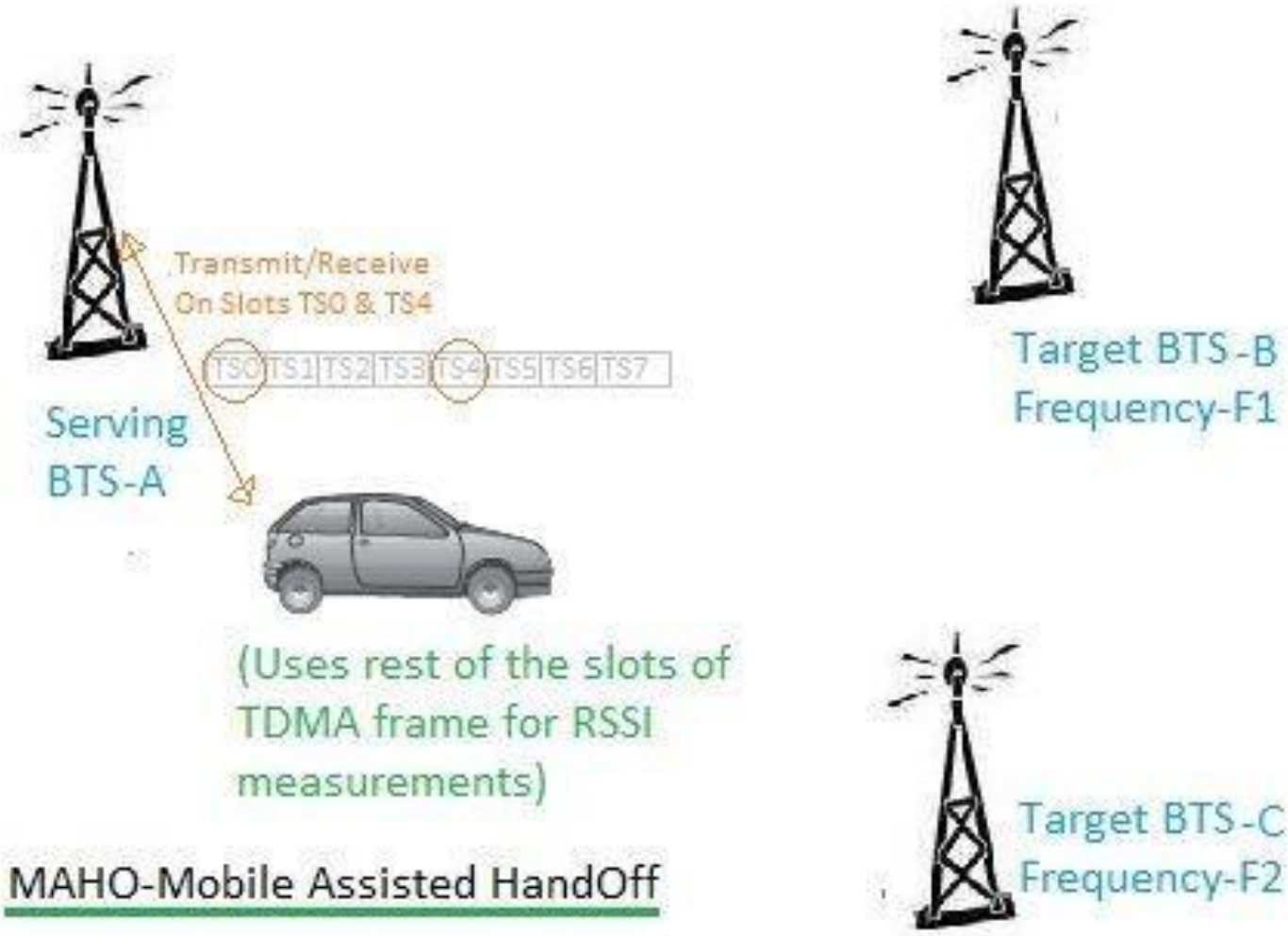
Total available number of channels = 4

(b)

Handover Strategies

Handoff Strategies in Mobile Communication: When a mobile moves into a different cell while a conversation is in progress the MSC automatically transfers the call to a new channel belonging to the new base station. This process of transferring the channels between two cells is called Hand-Off. These Handoff Strategies in Mobile Communication not only involves identifying a new base station, but also requires that the voice and control signals be allocated channels associated with the new base stations.

Mobile Assisted Handoff (MAHO) is a process used in GSM cellular networks where a mobile phone assists/helps the cellular base station to transfer a call to another base station. It is a technique used in mobile telecom to transfer a mobile phone to a new radio channel with stronger signal strength and improved channel quality. Mobile assisted handoff can also be referred to as mobile assisted handover.



MAHO-Mobile Assisted HandOff

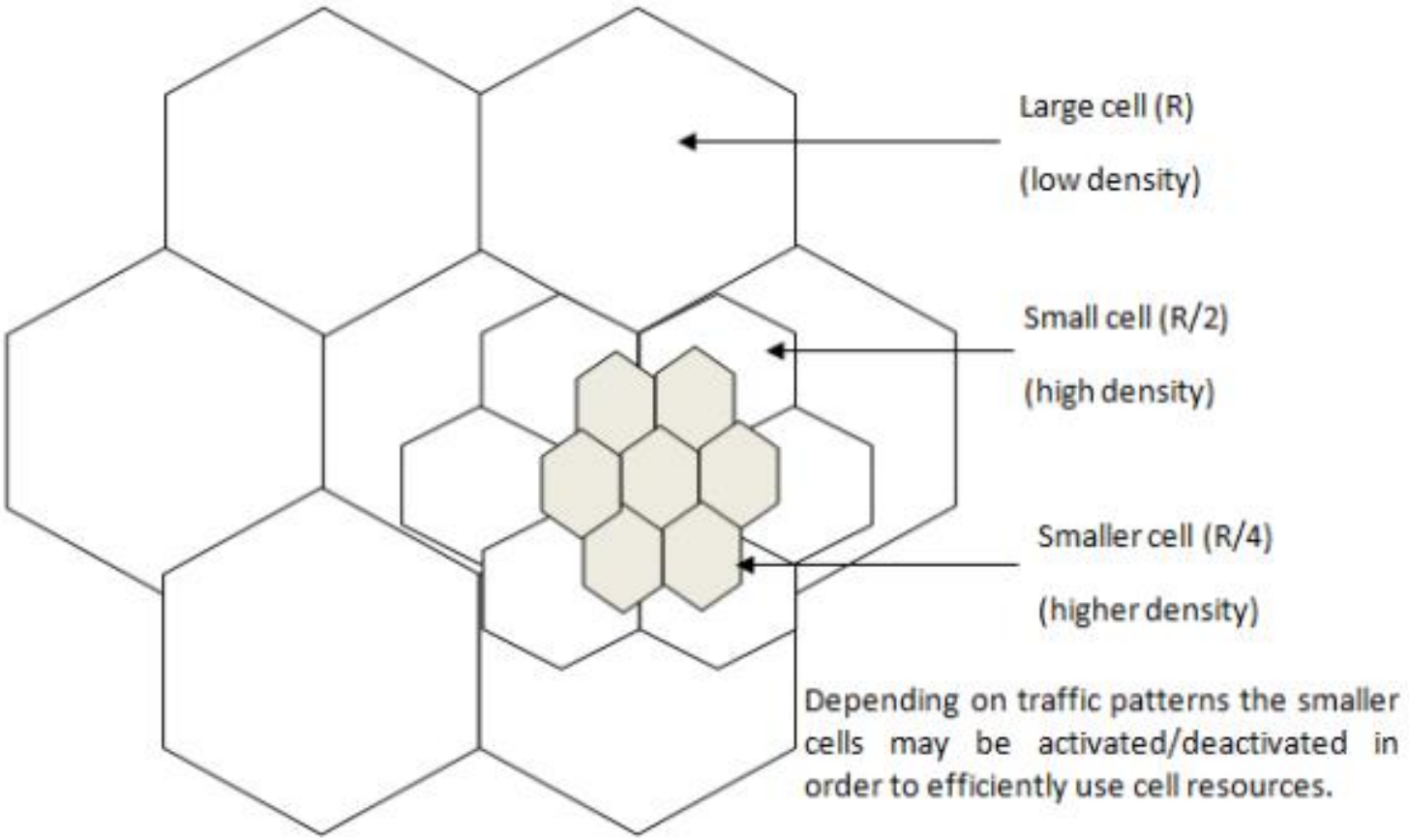
MAHO is based on a mobile phone's capabilities in detecting and identifying better radio channels to be used within a call. MAHO works when a mobile phone can scan, review and monitor nearby radio channels. The mobile collects the measurements, usually in the form of RF signal quality, received signal strength indication (RSSI), bit error rate and similar results from other available channels. These measurements are then sent to the base station, which evaluates them and transfers the call to the best available channel.

Cell dragging occurs when there is a line-of-sight (LOS) radio path between the subscriber and the base station. The user enters the neighboring cell without handoff. This creates a potential interference and traffic management problem. To solve the cell dragging problem, handoff thresholds and radio coverage parameters must be adjusted carefully.

Capacity Improvement

As the demand for wireless service increases, the number of channels assigned to a cell eventually becomes insufficient to support the required number of users. At this point, cellular design techniques are needed to provide more channels per unit coverage area. Techniques such as cell splitting, and sectoring are used in practice to expand the capacity of cellular systems.

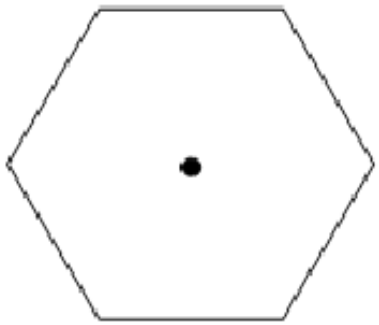
1- Cell splitting is the process of subdividing a congested cell into smaller cells, each with its own base station and a corresponding reduction in antenna height and transmitter power. Cell splitting increases the capacity of a cellular system since it increases the number of times that channels are reused. By defining new cells which have a smaller radius than the original cells and by installing these smaller cells (called microcells) between the existing cells, capacity increases due to the additional number of channels per unit area.



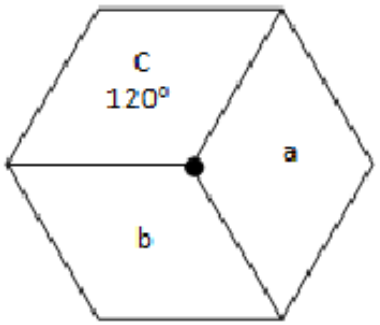
Cell splitting

The consequence of the cell splitting is that the frequency assignment has to be done again, which affects the neighboring cells. It also increases the handoff rate because the cells are now smaller and a mobile is likely to cross cell boundaries more often compared with the case when the cells are big. Because of altered signaling conditions, this also affects the traffic in control channels.

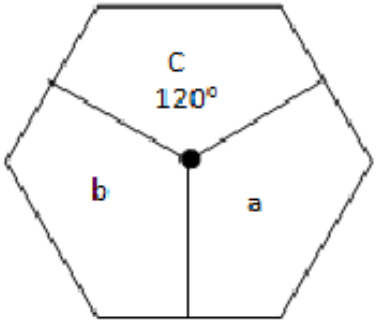
Cell sectoring gives a room for increasing capacity by keeping the cell radius unchanged and seeking methods to decrease (Distance/Raduis) D/R ratio. Sectoring increases signal-to-interference ratio (S/I) so that the cluster size may be reduced. In this approach S/I is improved by using directional antennas, then capacity improvement is achieved by reducing the number of cells in a clusters, thus, increasing the frequency reuse. However in order to do this successfully, it is necessary to reduce the relative interference without decreasing the transmit power.



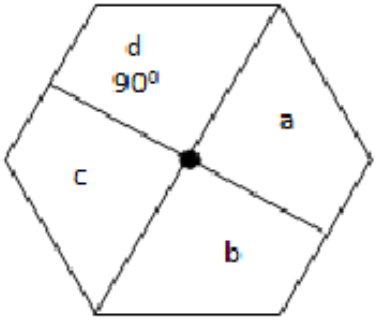
(a) Omni



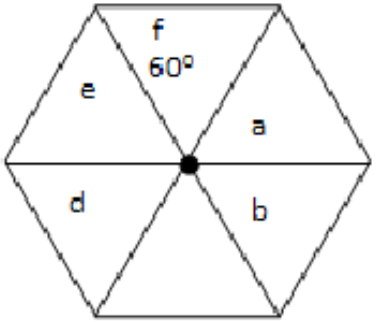
(b) 120° sector



(c) 120° sector (alternate)



(d) 90° sector



(e) 60° sector

several sector examples

The co-channel interference in a cellular system may be decreased by replacing a single omnidirectional antenna at the base station by several directional antennas, each radiating with a specified sector. By using directional antennas, as given cell will receive interference and transmits with only a fraction of the available co-channel cells. The technique for decreasing co-channel interference and thus increasing system performance by using directional antennas is called sectoring. The factor by which co-channel interference is reduced depends on the amount of sectoring used. A cell is normally partitioned into three 120^0 sectors or six 60^0 sectors.