*Impact Factor (SJIF): 3.632*

**International Journal of Advance Research in Engineering, Science & Technology**

*e-ISSN: 2393-9877, p-ISSN: 2394-2444*

***(Special Issue for ITECE 2016)***

# Improving the Scalability of Cellular Networks Using Frequency Reuse Technologies and Improving the Handoffs

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*Abstract* — **this paper contains the techniques to improve the scalability of cellular network by using different variant variants of cell splitting and cell sectoring. It also contain the hand off handling mechanism.**

***Keywords: Cellular network, cell sectoring, cell splitting, hand off, hand over***

## I. INTRODUCTION

A mobile network or cellular network is a communication network which uses the wireless links as the last link for communications. This network is distributed over geographical area called as cells. Each cell has at least one fixed transceiver which ia also known as base station and informally known as mobile tower. It provides the cell with network coverage which can be used for transmitting the voice data or packet data or others (video data etc.) n a cellular network, each cell uses a different set of frequencies from neighboring cells, to avoid interference and provide guaranteed bandwidth within each cell. Mobile-telephone nets these cells are usually hexagonal. In radio broadcasting, a similar concept has been developed based on rhombic cells. To ensure that the mutual interference between users remains below a harmful level, adjacent cells use different frequencies.

In fact, a set of C different frequencies {f1, ..., fC} are used for each cluster of Adjacent cells. Cluster patterns and the corresponding frequencies are re-used in a regular pattern over the entire service area.

In earlier days, the cellular networks normally used a high power transmitter with an antenna mounted on a tall tower. This method gave very good coverage. But it was very difficult to reuse the same frequencies. The available frequency for cellular network is limited. And day by day the number of users is growing. Without reusing the same frequency again and again, it was difficult to accommodate all the users. So to achieve high network capacity, it is inevitable to reuse the same frequency again. So the concept of frequency reuse was introduced. Logically the cells are divided into hexagons. But practically the cell is not hexagonal. The geographical area or cell coverage area is decided by performing some optimized planning for base station location [1]. Practically the cell structure may appear as shown in fig 1.

Fig 1: geographically allocated cells

## II. CELL SECTORING

The total available channels are divided into a number of channel sets (Actually, frequency reuse pattern is equally to the number of channel sets). Each channel set is assigned to a cell. Cells are assigned a group of channels that is completely different from neighboring cell. The same set of channels can be reused in another cell provided that the reuse distance D is fulfilled. The reuse distance is the minimum separation of identical channels that have the same carrier frequency, at which there is acceptable interference:

D= √3N R

The sectoring method increases the capacity. A cell has the same coverage space but instead of using a single omni-directional antenna that tranmits in all directions, it uses the directional antenna that provides coverage to a sector of the hexagon. When 3 directional antennas are used, 120 degree sectoring is achieved, and when 6 directional antennas are used, 60 degree is achieved.

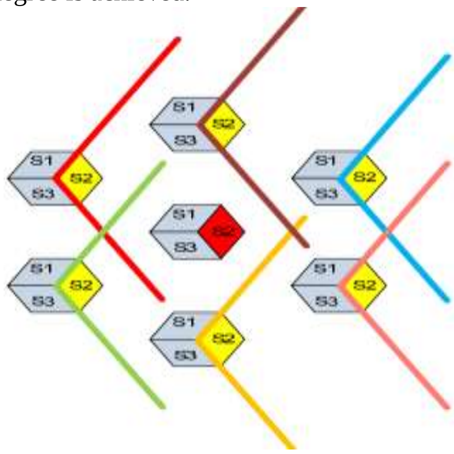


Fig2: cell sectoring

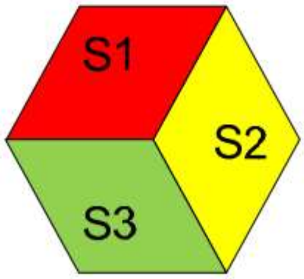


Fig 3: directional cell sectoring

Dividing the cells into sectors actually reduces the network capacity because the channels allocated to a cell are now divided among the different sectors. In fact, handoff takes place when a cell phone moves from one sector to another in the same cell. The gain in network capacity is achieved by reducing the number of interfering co-channel cells. If sectoring is done in a way that channels assigned to a particular sector are always at the same direction in the different cells (i.e., group A of channels is assigned to the sector to the left of the tower in all cells, and group B of channels is assigned to the sector at the top of all cells, and so on), each sector causes interference to the cells that are in its transmission angle only. Unlike the case of no sectoring where 6 interfering co-channel cells from the first-tier co channels cells cause interference, with 120° sectoring, 2 or 3 co-channel cells cause interference and with 60° sectoring, 1 or 2 co-channel cells cause interference. The number of co- channel interfering cells depends on the cluster shape and size. By having less than 6 interfering first-tier co-channel cells causing interference, the SIR is increased for the same cluster size. This allows us to reduce the cluster size and achieve the same original SIR, which directly increases the network capacity.

As seen in the figures below, for the case of cluster size of N = 4 , only 2 of the 6 co-channel cells cause interference to the middle cell for the sector labeled S2 in the case of 120° cell sectoring (the cells with radiation sectors colored red and green). The other 4 cells, although they are radiating at the same frequencies cause no interference because the middle cell is not in their radiation angles. For the case of 60° cell sectoring, only one cell causes interference (the cell with radiation sectors colored green).

## III. CELL SPLITTING

To minimize interference, a certain distance must be maintained between cells using the same frequencies. However, this distance can be reduced without disturbing the cell reuse pattern. As the size of the cells is reduced, the same frequencies can be utilized in more cells, which in turn mean more subscribers can be accommodated on the system.
Particularly in congested areas, the cellular operator often splits an existing cell into two or more smaller cells. New transceivers are placed and the power of the transmitters is reduced in order to confine the signals to the newly created cells.

For example, a cell that originally had a radius of 8 mi could be split into four cells with each new cell having a 2 mi radius. For the existing analog system, cell splitting is an effective way to increase system capacity, although some practical limitations are reached. Suitable locations for cell sites become more difficult and the processing load on the switch rapidly increases because handoffs are more frequent.

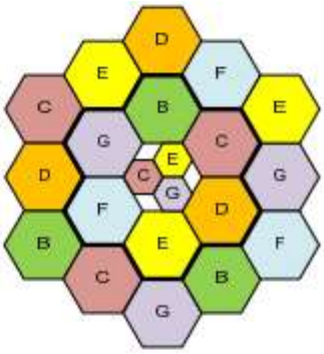


Fig 4: Cell splitting

## IV. Hand offs

Cellular networks are composed of cells, each of which is capable of providing telecommunications services to subscribers roaming within them. Each cell can only serve up to a certain area and number of subscribers. Thus, when any of these two limits is reached, a handoff ensues.

For instance, if a subscriber moves out of the coverage area of a particular cell while entering another, a handoff takes place between the two cells. The cell that served the call prior to the handoff is relieved of its duties, which are then transferred to the second cell. A handoff may also be triggered when the number of subscribers using a particular cell has already reached the cell's maximum limit (capacity).

Such a handoff is possible because the reach of the cell sites serving these cells can sometimes overlap. Thus, if a subscriber is within an overlapping area, the network may opt to transfer one subscriber's call to the cell involved in the overlap.

Sometimes a handoff can take place even if no limit is breached. For example, suppose that a subscriber initially inside the jurisdiction of a large cell (served by an umbrella-type cell site) enters the jurisdiction of a smaller cell (one served by a micro cell). The subscriber can be handed off to the smaller cell in order to free up capacity on the larger one.

Handoffs may be classified into two types
Hard Handoff: Characterized by an actual break in the connection while switching from one cell or base station to another. The switch takes place so quickly that it can hardly be noticed by the user. Because only one channel is needed to serve a system designed for hard handoffs, it is the more affordable option. It is also sufficient for services that can allow slight delays, such as mobile broadband Internet.

Soft Handoff: Entails two connections to the cell phone from two different base stations. This ensures that no break ensues during the handoff. Naturally, it is more costly than a hard handoff

### A) Network- Controlled Handoff

In an NCHO protocol, the network makes a handoff decision based on measurements of the RSSs of the MS at a number of BSs. Sometimes the network sets up a bridge connection between the old and new BSs and thus minimizes the duration of handoff. In general, the handoff process (including data transmission, channel switching, and network switching) takes 100–200 ms and produces a noticeable click in the conversation. This click is imperceptible in a noisy voice channel; however, it is perceptible when handoff occurs at a reasonable signal quality [50]. Information about the signal quality for all users is located at a single point (the MSC). This information facilitates resource allocation. the overall delay can be of the order of 5–10 s. This type of handoff is not suitable for a rapidly changing environment and a high density of users due to the associated delay. NCHO is used in first-generation analog systems such as AMPS, Total Access Communications System (TACS), and Nordic Mobile Telephone (NMT)

### B) Mobile-Assisted Handoff

An MAHO protocol distributes the handoff decision process. The MS makes measurements, and the MSC makes decisions. According to, there can be a delay of 1 s; this delay may be too much to counteract the corner effect. In GSM, the BS subsystem (BSS) includes a base transceiver station (BTS) and a base station controller (BSC). The BTS is in contact with MSs through the radio interface and includes radio transmission and receiver devices and signal processing.

The BSC is in contact with the network and is in charge of the radio interface management, mainly the allocation and release of radio channels and handoff management. One BSC serves several BTSs, and several BSCs are connected to one MSC. The handoff time (the time between handoff decision and execution) in GSM is approximately 1 s [3]. If the serving and target BTSs are located within the same BSS, the BSC for the BSS can perform handoff without the involvement of the MSC. This is referred to as intra-BSS handoff. When the MSC coordinates the handoff process, such handoff can further be classified as intra-MSC (within the same MSC) or inter-MSC (between MSCs) [5]. GSM-based handoff algorithms are evaluated.

### C) Mobile-Controlled Handoff

In MCHO the MS is completely in control of the handoff process. This type of handoff has a short reaction time (on the order of 0.1 s) and is suitable for microcellular systems [5]. The MS does not have information about the signal quality of other users, but handoff must not cause interference to other users. The MS measures the signal strengths from surrounding BSs and interference levels on all channels. A handoff can be initiated if the signal strength of the serving BS is lower than that of another BS by a certain threshold. The MS requests the target BS for a channel with the lowest interference. MCHO is the highest degree of handoff decentralization. Some of the advantages of handoff decentralization are that handoff decisions can be made fast, and the MSC does not have to make handoff decisions for every mobile, which is a very difficult task for the MSC of high-capacity microcellular systems [6]. MCHO is used in the European standard for cordless telephones, DECT [3]. The MS and BS monitor the current channel, and the BS reports measurements — RSS and bit error rate (BER) — to the MS. The C/Is of free channels are also measured. The handoff decisions are made by the MS. Both intracell and intercell handoffs are possible. The handoff time is approximately 100 ms.

## V. Conclusion

As the number of users is increasing day by day, we need more frequency reuse techniques; there are many variants of cell sectoring and cell splitting. Cell splitting may be used when there are more users in small geographical area. Cell sectoring can be used with directional antennas. Hand offs occurs when the cell migrates from one hexagon to other hexagon. Handoff algorithms with a specific set of parameters cannot perform uniformly well in different communication system deployment scenarios since these scenarios impose distinct restrictions and peculiar environments on the handoff process. Such system scenarios are illustrated. These system structures are expected to co-exist in future wireless communication systems and warrant substantial study. Handoff prioritization can improve handoff related system performance. Two basic handoff prioritization schemes, guard channels and queuing, are discussed. Handoff represents one of the radio resource management tasks carried out by cellular systems. Some other resource management functions include admission control, channel assignment, and power control. If the resource management tasks are treated in an integral manner, better overall performance can be obtained to achieve global goals by making appropriate trade-offs. Such integrated resource management is discussed briefly. Different systems use different approaches to execute the process of handoff, and handoff protocols that characterize these approaches are explained.

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