

Cellphone signals & Cell Splitting

Cellphone signals

Although there are cell phone base station tower networks across many nations globally, there are still many areas within those nations that do not have good reception. Some rural areas are unlikely ever to be effectively covered since the cost of erecting a cell tower is too high for only a few customers. Even in high reception areas it is often found that basements and the interiors of large buildings have poor reception.

Weak signal strength can also be caused by destructive interference of the signals from local towers in urban areas, or by the construction materials used in some buildings causing rapid attenuation of signal strength. Large buildings such as warehouses, hospitals and factories often have no usable signal further than a few metres from the outside walls.

This is particularly true for the networks which operate at higher frequency since these are attenuated more rapidly by intervening obstacles, although they are able to use reflection and diffraction to circumvent obstacles.

Cell phones in the U.S. operate at around 800 MHz and PCS phones at 1900 MHz, classified as UHF and low energy microwaves respectively. This has led to the rapid growth in the home cellular repeater market. The more advanced models now typically include an external directional antenna and an amplifier (usually operating at 55 dB gain), which is generally enough to turn a very weak signal into a clear one over the local area (from around a thousand square feet to over twenty thousand).

Cell Splitting is based on the cell radius reduction and minimizes the need to modify the existing cell parameters. Cell splitting involves the process of sub-dividing a congested cell into smaller cells, each with its own base station and a corresponding reduction in antenna size and transmitting power. This increases the capacity of a cellular system since it increases the number of times that channels are reused.

Since the new cells have smaller radii than the existing cells, inserting these smaller cells, known as microcells, between the already existing cells results in an increase of capacity due to the additional number of channels per unit area. There are few challenges in increasing the capacity by reducing the cell radius. Clearly, if cells are small, there would have to be more of them and so additional base stations will be needed in the system. The challenge in this case is to

introduce the new base stations without the need to move the already existing base station towers. The other challenge is to meet the generally increasing demand that may vary quite rapidly between geographical areas of the system. For instance, a city may have highly populated areas and so the demand must be supported by cells with the smallest radius. The radius of cells will generally increase as we move from urban to sub urban areas, because the user density decreases on moving towards sub-urban areas. The key factor is to add as minimum number of smaller cells as possible

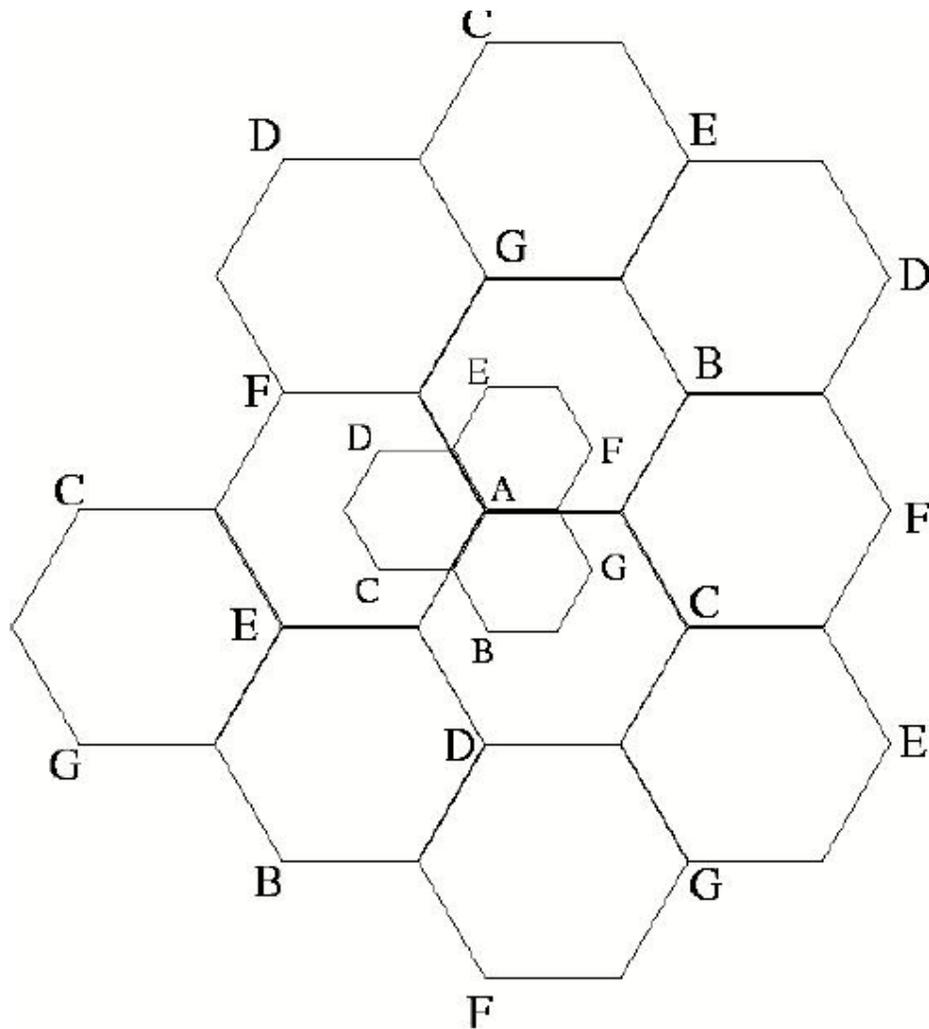


Figure : Splitting of congested seven-cell clusters.

wherever an increase in demand occurs. The gradual addition of the smaller cells implies that, at least for a time, the cellular system operates with cells of more than one size. Figure shows a cellular layout with seven-cell clusters. Consider that the cells in the center of the diagram are becoming congested, and cell A in the center has reached its maximum capacity. Figure also shows how the smaller cells are being superimposed on the original layout. The new smaller cells have half the cell radius of the original cells. At half the radius, the new cells will have one-fourth of the area and will consequently need to support one-fourth the number of subscribers. Notice that one of the new smaller cells lies in the center of each of the larger cells. If we assume that base stations are located in the cell centers, this allows the original base stations to be maintained even in the new system layout. However, new base stations will have to be added for new cells that do not lie in the center of the larger cells. The organization of cells into clusters is independent of the cell radius, so that the cluster size can be the same in the small-cell layout as it was in the large-cell layout. Also the signal-to-interference ratio is determined by cluster size and not by cell radius. Consequently, if the cluster size is maintained, the signal-to-interference

ratio will be the same after cell splitting as it was before. If the entire system is replaced with new half-radius cells, and the cluster size is maintained, the number of channels per cell will be exactly as it was before, and the number of subscribers per cell will have been reduced. When the cell radius is reduced by a factor, it is also desirable to reduce the transmitted power. The transmit power of the new cells with radius half that of the old cells can be found by examining the received power P_R at the new and old cell boundaries and setting them equal. This is necessary to maintain the same frequency re-use plan in the new cell layout as well. Assume that P_{T1} and P_{T2} are the transmit powers of the larger and smaller base stations respectively. Then, assuming a path loss index $n=4$, we have power received at old cell boundary = P_{T1}/R^4 and the power received at new cell boundary = $P_{T2}/(R/2)^4$. On equating the two received powers, we get $P_{T2} = P_{T1} / 16$. In other words, the transmit power must be reduced by 12 dB in order to maintain the same S/I with the new system lay-out.

At the beginning of this channel splitting process, there would be fewer channels in the smaller power groups. As the demand increases, more and more channels need to be accommodated and hence the splitting process continues until all the larger cells have been replaced by the smaller cells, at which point splitting is complete within the region and the entire system is rescaled to have a smaller radius per cell. If a cellular layout is replaced entirely by a new layout with a smaller cell radius, the signal-to-interference ratio will not change, provided the cluster size does not change. Some special care must be taken, however, to avoid co-channel interference when both large and small cell radii coexist. It turns out that the only way to avoid interference between the large-cell and small-cell systems is to assign entirely different sets of channels to the two systems. So, when two sizes of cells co-exist in a system, channels in the old cell must be broken down into two groups, one that corresponds to larger cell reuse requirements and the other which corresponds to the smaller cell reuse requirements. The larger cell is usually dedicated to high speed users as in the umbrella cell approach so as to minimize the number of hand-offs.

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